LA-UR-19-32444
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| Title: | Surveillance Report on SAVY 4000 and Hagan Nuclear Material Storage Containers Update for Fiscal Year 2019 |
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| Intended for: | Report |
| Issued: | 2019-12-24 (rev.1) |

# Surveillance Report on SAVY 4000 and Hagan Nuclear Material Storage Containers Update for Fiscal Year 2019

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## Executive Summary

A Surveillance Program is in place to assess how nuclear material storage containers at LANL are aging in-service. This program is guided by the LANL Surveillance Plan [1] which is required by DOE M441.1-1. The plan is modified as necessary to ensure that any issues identified during surveillance or laboratory studies are examined in future surveillances, and that any lifetime implications are taken into account. Under the plan, overall container integrity is evaluated by a combination of visual inspections and photographs. Multiple measurements are made to assess the SAVY 4000 performance, including, helium leakage rate, O-ring hardness (durometer), O-ring compression set, filter performance and filter water resistance. The containers for surveillance are chosen annually based on the previous surveillance program results and observations. The surveillance plan targets items believed to provide the greatest challenge to the SAVY 4000 container integrity.

Surveillance items for FY19 consisted of 10 SAVY 4000 storage containers, 9 Hagan containers, and 19 SAVY 4000 transfer containers. The FY19 SAVY 4000 storage containers ranged in age from 3.5 years to 7.9 years and the Hagan containers ranged in age from 11.2 years to 19.4 years. As in FY18, the surveillance containers for this year were selected primarily to better understand the extent of corrosion of the stainless steel components of the containers. Accelerated aging studies indicate that the O-ring and filter components of the SAVY 4000 will last at least 40 years under LANL storage conditions, and surveillance test results are consistent with the conclusions from those studies. However, the observation of corrosion on the inside of SAVY 4000 and Hagan surveillance containers has shifted the emphasis to an ongoing effort to understanding both the nature and the extent of corrosion on the stainless components, primarily the container body. The restriction on handling soluble residues greater than 500 grams continued in FY19, thus limiting the ability to perform surveillance on materials that are even more challenging to the containment barrier, e.g., higher heat load, higher radiation, higher chloride content, etc. Items >500 grams that were identified for surveillance in the FY19 plan will be reconsidered for processing in FY20 and beyond.

Out of the nine Hagans containers surveilled this year, three of them had to be introduced into a glovebox due to potential or actual contamination found in the containers. The data presented on these three items are based on photographs. The need to introduce many of the items into a glovebox is not surprising given that surveillance items are specifically chosen to be the most challenging to the containment barrier, and the bag-out bag is

likely to be degraded and/or breached. Unfortunately, introduction into the glovebox currently limits the ability to perform quantitative tests on the container seals, the filters, and the stainless steel components. In FY18 a systematic categorization methodology for ranking the degree of corrosion based on photographic evidence was developed and has been applied to all surveillance containers to date. In addition to this report, the surveillance results to date are documented in four previous surveillance reports [2] [3] [4] [5].

A high-level summary of the surveillance results for the SAVY and Hagan containers this year is as follows:

- **Container Integrity**— A combination of visual inspections and photographs on 10 SAVY containers and 6 Hagan containers revealed that 4 of the 10 SAVY containers and 5 of the 6 Hagan containers had corrosion. The corrosion on the SAVYs did not compromise the container integrity based on acceptable He leakage, durometer, filter and water ingress test results. One of the SAVYs inspected had an excessive amount of corrosion on inner surfaces and was judged to be unacceptable for continued use. The remaining 9 SAVY containers were returned to service for continued surveillance with the same content. All of the 10 SAVY and 6 Hagan containers that underwent formal visual inspection passed functional checks of the closure system with no other signs of damage. The material in the Hagan containers was either processed or repackaged into SAVY containers.
- **O-rings**—O-ring visual inspections, durometer measurements and helium leakage testing were completed on all 10 SAVY and 6 Hagan containers. Four SAVY 4000 O-rings were found to have small flaws (likely manufacturing defects), but they were not substantial enough to compromise the O-ring seal as determined by helium leak testing. All 10 SAVY containers evaluated passed the helium leakage test criteria, O-ring visual inspection criteria, and durometer specifications. A single Hagan container with substantial general corrosion failed the helium leakage test. Further testing is underway to determine the cause of failing the helium leakage rate. The other Hagans passed all test criteria. Helium leakage testing results also confirmed that the containment system for the 10 SAVYs and 5 Hagan tested were fully intact.
- **Filters—**Only 7 of the 10 SAVY container filters were tested due to technical challenges encountered with the Filter Test System. No issues were found with the Hagan lid filters tested. The 7 SAVY and 6 Hagan containers met the test criteria for aerosol capture and pressure drop indicating no degradation in efficiency and no evidence of filter clogging for those containers that were tested.
- **Water Resistance—**All containers that underwent surveillance activities passed the water resistance test criteria of no water penetration after 1 minute of exposure to 12 inch water column pressure.
- **Annual Surveillance and Trending Analysis—** Analysis of results on the annual testing of five surveillance containers and trending analysis (Section 4.3) of all measurements performed during surveillance testing on SAVY containers

(helium leak, O-ring, durometer, compression set, and filter performance) over the past 6 years showed no significant change in performance over this period.

Key recommendations from the FY18 surveillance report are progressing as follows:

- In FY19 a laser micrometer was introduced into a glovebox to allow for compression set measurements to be made in the glovebox line expanding the capabilities of the surveillance activities. No SAVYs were introduced in FY19 so there was no need to employ this new capability (compression set is not measured on Hagan o-rings).
- A strategy was developed in FY19 to incorporate a random sampling into the surveillance program, which in time will give increasing confidence that the SAVY 4000 surveillance program is identifying unforeseen container issues. The random sampling will begin in FY20.
- A Pu-242 item was surveilled in FY19, expanding the different types of materials that have been surveilled in the SAVY 4000 surveillance program.
- The new Aromatic Polyurethane bag-out bag material has been used to sample out the item from 19H5. This item is expected to provide a challenging environment to the bag material, and the condition of the bag material and degree of container corrosion will be evaluated in future surveillance activities.
- The establishment of enhanced photographic capabilities was deemed low priority, but will be considered in FY20.

Recommendations from observations in this report are described in Section 6, and the FY20 version of the Surveillance Plan will be adjusted accordingly.

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# 1 Introduction

Approximately 1603 Storage SAVY 4000 containers are in use at Los Alamos National Laboratory (LANL), and although Hagan containers are being phased out, there are still ~3073 loaded Hagan containers in storage. The initial design lifetime for a SAVY 4000 container is 5 years, starting in April 2014. The lifetime extension program was initiated to determine how long a SAVY 4000 container may be used safely, extending the design lifetime of the containers and avoiding unnecessary maintenance, replacement of containers or components, and handling of radioactive materials. In fiscal year 2019 an extension was granted for 10 years by the Los Alamos Field Office making the overall lifetime of the SAVY 4000 15 years. The surveillance program was initiated to observe SAVY 4000 and Hagan containers during usage, and information from both surveillance and lifetime extension programs is used to build a comprehensive picture of the behavior of storage containers over time. At LANL, SAVY 4000 containers are designated as either storage containers or transfer containers as defined in TA55-DOP-091, “TA-55 Nuclear Material Packaging.” The primary difference is that storage containers are designed to function without maintenance over their entire lifetime, and transfer containers have a design life limited to 1 year and require an annual visual inspection to re-certify. Once a transfer container has been used for 5 years it is more rigorously tested using the full surveillance suite i.e. container visual inspection, o-ring visual inspection, thickness measurements and durometer testing, helium leakage rate check, filter efficiency, filter pressure drop and water ingress testing.

This work was performed for the surveillance program in accordance with the surveillance plan, “Los Alamos National Laboratory SAVY 4000 Field Surveillance Plan Update for 2019” [1]. The purpose of the surveillance plan and surveillance activities is to perform the following:

- Ensure that the containers currently in service are functioning properly
- Identify any unexpected problems in the containers or components
- Evaluate container component degradation over time against initial baseline measurements
- Contribute to the lifetime extension studies having met an initial goal of accumulating enough data within the initial 5-year design lifetime to extend the service lifetime of the SAVY 4000 container [6].

Containers with contents that represent upper bounding conditions were selected for surveillance, as detailed in the surveillance plan [1]. This report includes surveillance testing results gathered over 1 year on a total of 10 SAVY 4000 containers and 9 Hagan containers.

# 2 Surveillance Examinations

This section describes the surveillance examinations of the SAVY 4000 storage and transfer containers and the Hagan containers, along with their respective O-rings and filters.

## 2.1 Inspection

### 2.1.1 Container

Inspection of the containers begins during unpacking and includes checking for external corrosion, evidence of pressurization, and dents or gouges that may have occurred during handling. The container is weighed, and a contamination survey is conducted before the container is opened. When the container is opened, the bag-out bag is inspected for signs of compromised integrity such as discoloration, brittleness, or the presence of liquid and the interior of the outer container is surveyed for contamination. The packaging configuration is verified for compliance with facility requirements, and the outer container is checked for corrosion or the presence of liquid. The visual inspection continues when the outer container is emptied and then released to the package-engineering team for further evaluation. The empty container is then checked for proper function of the closure mechanism, damage to the O-ring groove in the lid or on the body collar's sealing surface, filter discolorations or occlusions, and evidence of corrosion. If deemed necessary by a subject matter expert, the weld at the collar-body interface may be tested as well, but no welds were tested during the past years.

### 2.1.2 O-ring

Visual inspection of each O-ring was conducted according to PA-DOP-01080 Rev.1, "Surveillance Inspections of O-Rings for Nuclear Material Storage Containers," using a 4-inch, illuminated magnifying lens to look for O-ring defects such as flashing; mold mismatch; damage to the O-ring, such as cuts or abrasions; and the presence of dirt, hair, or dust on the O-ring. Irregularities were noted on the inspection sheet and corrected by cleaning, if possible.

## 2.2 Tests

### 2.2.1 Helium Leakage Rate

The leakage rate for each SAVY 4000 container with its original O-ring installed was measured in the inside-out mode using a LACO Flexstation™ bell-jar helium mass-spectroscopy leakage tester according to the procedure in PA-AP-01158 Rev. 0, "Helium Leakage Test Procedure of the SAVY 4000." The leakage tester detects the presence of a leakage by analyzing for helium leakage into a bell jar held near vacuum when the container is charged with 75 Torr of helium.

The O-ring passes the leakage test if the measured leakage rate is below a threshold value of $1\times10^{-5}$ atm cc $s^{-1}$. That threshold value was determined for leakage rate testing of SAVY 4000 container O-rings in Section 5.2 of the SAVY 4000 safety analysis report [7].

A single-point calibration is done before the measurements are taken each day. During FY19, the calibration standard used had a value of $1.05 \times 10^{-7}$ atm. cc/s. This value is low enough to ensure that a leakage at the threshold value will register on the leakage detector, but it is high enough to be distinguishable from the typical background leakage rate.

The sensitivity of the measurement is limited by the quantity of helium in the ambient atmosphere, which can come from helium diffusing out of porous parts in the leakage tester from prior tests. This helium contributes to an apparent background leakage rate. A background measurement was taken before each measurement.

### *2.2.2 O-ring Hardness*

The hardness of each O-ring was measured by durometer, according to PA-DOP-01080 Rev. 1, “Surveillance Inspections of O-Rings for Nuclear Material Storage Containers,” on the Shore-M scale. The hardness value for each O-ring was taken as the average of five durometer measurements taken at arbitrary but different positions around the whole O-ring. The calibration of the durometer is checked before and after each day of surveillance testing, using known calibration hardness standards.

### *2.2.3 O-ring Compression Set*

The compression set of the O-rings used in the storage containers was estimated from a measurement of the O-ring thickness several weeks after they were removed from their containers as part of the SAVY 4000 surveillance program. The initial thickness of the O-rings was $5.333 \pm 0.045$ mm, derived from the average of 85 unused O-rings, measured three times each. The compressed thickness was taken to be the gland depth of the container, which was determined by finding the best value for the difference between the lid sealing diameter and the collar sealing diameter, measured as part of the inspection process. If measurements were unavailable, the mean value for that particular batch and size of container was taken from those surveyed in the receipt inspections. The final thickness measurement was taken by suspending the O-ring within the beam of a laser micrometer and averaging eight measurements at arbitrary positions around the O-ring. The uncertainty varied with the precision of the values available for each calculation, but generally was in the range of 5%–8%.

### *2.2.4 Filter Efficiency*

In FY19 the Filter Test System (FTS) was not operable. During the time that the FTS was out of service three time sensitive SAVY surveillances were performed not allowing the filter functionality to be tested. Seven SAVY and six Hagan filters were subjected to particle penetration testing, in which the concentration of a test aerosol is measured downstream of the filter per PA-DOP-01580 Rev. 1. The test aerosol used was polyaphla-olefin with a concentration of $65 \pm 15$ µg/L upstream of the filter. The concentration was measured using an Air Techniques International (ATI) 2H photometer, which was modified by ATI for the test flow rate of 200 cc/min. The filters must capture at least 99.97% of the challenge aerosol. The development of this instrument and calibration information is discussed in LA-UR-16-20507, “Development and Use of a Low-Flow Filter Test System for the Filters Used in Special Nuclear Material Storage Containers”.

### 2.2.5 Filter Pressure Drop

Seven SAVY and six Hagan filters were subjected to pressure drop testing per PA-DOP-01580 Rev. 1. The pressure drop tests were performed in conjunction with the aerosol tests. After the upstream aerosol concentration is measured, the instrument is switched to measure the concentration downstream of the filter, where the data system records 15 pressure drop data values in one-second intervals. The first two data points are discarded because there is an interval with a momentary spike in the system pressure. The pressure drop must be <1 inch water column at a flow rate of 200 cc/min to be considered passing.

### 2.2.6 Water Penetration Testing

A selection of SAVY 4000 containers underwent water penetration testing using PA-DOP-01768 Rev. 1, “Surveillance Inspections of Filter Water Resistance”. A pressure of water at 12” water column was applied to the filter on the outside of the lid and the pressure was held for 1 minute. The opposite side of the filter was monitored during the 1-minute interval to check for any water penetration. If no penetration was observed, the filter was considered to have passed the test. This test is comparable to the water penetration test performed at the time of container manufacture. All filters water penetration tested in FY19 passed the water ingress test.

### 2.2.7 Corrosion Evaluation

The visual inspection of SAVY 4000 and Hagan containers includes an evaluation of the corrosion found on container surfaces. Any corrosion observed during the visual inspection is documented and photographed. In an effort to better understand the conditions under which corrosion occurs, a numeric ranking was assigned to each surveillance container from FY13 through FY19. The numeric ranking describes the severity of the corrosion based on its overall appearance with consideration for the relative coverage and density of the corrosion. The numeric ranking ranges from 0, which indicates no corrosion to a ranking of 3, which is the most severe. The ranking can be used to compare the corrosion behavior for various material forms and material types as well as to assess the progression of corrosion over time. The levels of numeric rankings are defined in Table 1 below.

**Table 1. Numeric Ranking for General Corrosion in SAVY 4000 and Hagan Containers**

| Numeric Ranking | Description | Criteria |
|---|---|---|
| **0** | No Corrosion | No corrosion, staining, spots, or coatings observed |
| **1** | Isolated General Corrosion | Corrosion, staining, spots, or coatings observed in isolated areas (e.g. corrosion found on weld only) |
| **2** | Light General Corrosion | Corrosion, staining, spots, or coatings throughout container; light in overall density; bare metal visible |
| **3** | Heavy General Corrosion | Corrosion, staining, spots, or coatings throughout container; heavy (dark) in overall density; little or no bare metal visible |

# 3 Materials and Containers

For FY2019 surveillance, the selection criteria were updated based on the corrosion identified in previous years. Containers were selected based on the material form (e.g., radiation, corrosive or gas generating potential), wattage (e.g., high Am), container size (e.g., ≤5 Qt) and the age (e.g., as old as possible) of the containers. The age of the container was calculated as the time between the initial packaging and the date of the surveillance measurements. The history of the material form was also considered, e.g., items were included which had previously been found to cause corrosion. The 2017 surveillance plan forward also added Hagan containers to evaluate containers that have been in storage for longer than any SAVY 4000. These containers were added due to the age of the containers, the similar material of construction (304L for Hagan, 316L for SAVY 4000), and the fact that the containers are still in storage and likely will be for at least a decade. The 316L components of the SAVY 4000 containers are expected to be more corrosions resistant than 304L components of the Hagan containers.

Table 2 provides a roadmap of all the containers tested. Where available, the SN for the SAVY-4000 container packaged with the material originally packaged inside the Hagan container is included. Also included in the table are the container ages and the thermal power. The plutonium mass ranges from 4 g to 2355.6 g. The physical and chemical forms cover a broad range, including compounds (Pu dioxide and Pu chloride), metals (unalloyed Pu metal), and process residues (filter residue, direct oxide reduction [DOR] salt, incinerator ash, ER salt, and molten salt extraction [MSE] salt). The isotopics of the materials range from weapons grade Pu (MT 52) to fuel grade Pu (MT 54-57), high americium items (MT 5X+44, MSE salts), and heat source Pu (MT 83). The thermal power ranges from 0 W to 19.7 W. The age (time in service) of the Hagan containers ranges from 4.8 to 19.4 years, and the age of the SAVY 4000 containers ranges from 0.84 to y7.6 years (over the entire surveillance program).

**Table 2. Roadmap for the Hagan and SAVY 4000 surveillance containers and their contents**

| Surv # | FY | Chemical Subform | Material Type | Material Name | Hagan SN | SAVY SN | Pu-239 (g) | Container Age (y) | Thermal Power (W) | Corrosion Ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| 13H1 | 2013 | MSE Salt | 52+44 | CAXBL128D | 8/02 LANL-813, 30142 | 111103 026 | 835 | 8.55 | 13.4 | 2 |
| 13H2 | 2013 | ER Salt | 52 | GBS005 | 4/02 A-28, 04/02-08028 | 041208 025 | 1875 | 8.22 | 4.9 | 1 |
| 13H3 | 2013 | ER Salt | 52 | GBS059 | 4/02 A-207, 04/02-08010 | 041208 004 | 1877 | 8.22 | 4.9 | 2 |
| 13H4 | 2013 | Incinerator Ash | 54 | INCA-20 | 4/99 LANL-429, 05/99 NMC 08000-305 | 041208 043 | 830 | 7.93 | 3.4 | 2 |
| 13H5 | 2013 | Incinerator Ash | 54 | INCA-21 | 4/99 LANL-405, 04/02-08145 | 041208 009 | 913 | 8.3 | 3.8 | 2 |
| 13H6 | 2013 | MgO | 52 | ORF633956X BLC | 2/99 LANL-83, 80208 | 041208 038 | 248 | 13.17 | 0.7 | n/a |
| 13H7 | 2013 | Salt | 52 | PCS68B1 | 4/02 A-134, 08/06-08077 | 041208 028 | 811 | 4.82 | 2.1 | n/a |
| 13H8 | 2013 | Tetra-fluoride | 54 | PHX5R4 | 8/05 LANL-2282, 08/05-03282 | 121103 052 | 166 | 6.45 | 0.7 | 0 |
| 13H9 | 2013 | Sweepings/Screenings | 52 | POX4275C1 | 7/02 LANL-393, 06/02-05183 | 091205 182 | 1037 | 7.56 | 2.73 | 0 |
| 13H10 | 2013 | Dioxide | 56 | RBXS5657-1A | 7/02 LANL-515, 06/02-05305 | 041205 026 | 751 | 8.81 | 3.8 | 2 |

| Surv # | FY | Chemical Subform | Material Type | Material Name | Hagan SN | SAVY SN | Pu-239 (g) | Container Age (y) | Thermal Power (W) | Corrosion Ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| 13H11 | 2013 | DOR Salt | 52 | SLTF3123A | 8/99 LANL-1178, 07/02-03184 | 121103 062 | 1900 | 7.84 | 5 | 0 |
| 13H12 | 2013 | Salt | 52 | SWPVTB15 | 08/02 LANL-897, 08/05-03300 | 111103 001 | 678 | 5.77 | 1.8 | n/a |
| 13H13 | 2013 | Sweepings/Screenings | 52 | VTB-16C1 | 4/02 A-164, 04/02-05164 | 021205 029 | 1013 | 7.49 | 2.7 | n/a |
| 13H14 | 2013 | MgO | 52 | XBLC9413 | 2/99 LANL-80, 80207 | 041208 055 | 356 | 13.34 | 0.9 | n/a |
| 13H15 | 2013 | MSE Salt | 56+44 | XBLS25 | 10/99 LANL-1932, 80234 | 041208 031 | 430 | 7.84 | 12.4 | n/a |
| 13H16 | 2013 | DOR Salt | 52 | XBSOX153 | 3/06 LANL-296, 03/06-05296 | 091205 175 | 1079 | 6.33 | 2.84 | 0 |
| 15H1 | 2015 | Dioxide | 52 | MOX51T | 8/99-LANL-1277, 06/02-05305 | 121103 054 | 2355.6 | 14.43 | 6.2 | 2 |
| 15H2 | 2015 | ER Salt | 52 | XBS9455 | 5/01-LANL-53, 08/99NMC03-000-125 | 121103 078 | 382.5 | 12.36 | 1 | 1 |
| 15H3 | 2015 | Dioxide | 57 | BLO-39-11-16 | 3/01-LANL-209, | 111308 080 | 544 | 5.62 | 5 | 3 |
| 15H4 | 2015 | Dioxide | 56 | RBXS5657-2A | LANL-441, 04/02-08049 | 081305 197 | 2059 | 11.48 | 10.5 | 3 |
| 16H1 | 2016 | Dioxide | 54+44 | XBPS333 | N/A | N/A | 80 | 8.1 | 2.9 | 3 |

| Surv # | FY | Chemical Subform | Material Type | Material Name | Hagan SN | SAVY SN | Pu-239 (g) | Container Age (y) | Thermal Power (W) | Corrosion Ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| 17H1 | 2017 | Chloride | 52 | ATLAMS1S1 | 07/02-03259 8/02 LANL-1014 | N/A | 75 | 11.10 | 0.2 | 2 |
| 17H2 | 2017 | Chloride | 52 | CASLT966 | 0702-03261 LANL1061 | N/A | 286 | 12.02 | 0.6 | 1 |
| 17H3 | 2017 | Filter Residue | 52 | CXLRES091599 | 05/99-NMC05-000-079, LANL-45 | N/A | 75 | 17.58 | 0.4 | 0 |
| 17H4 | 2017 | Incinerator Ash | 52 | ASHX09 | 05/99-NMC03-000-192, LANL-1344 | N/A | 4 | 16.16 | 0 | 0 |
| 17H5 | 2017 | Dioxide | 83 | 10/10-01076 (Pu238) | 10/10-01076 10-10 LANL-418 | N/A | (blank) | 6.27 | 19.7 | 1 |
| 17H6 | 2017 | ER Salt | 52 | XORER6SLT2 | 0402-08245 A245 | N/A | 457 | 11.63 | 1.2 | 0 |
| 17H7 | 2017 | MSE Salt | 56 | XBLS8A | 0805/03142 LANL2139 | N/A | 114 | 10.67 | 3.5 | 2 |
| 17H8 | 2017 | MSE Salt | 52 | XBSOX448A | 08/06-01050 06/00 LANL-98 | N/A | 56 | 17.41 | 0.9 | n/a |
| 18H1 | 2018 | Residue; Incinerator Ash | 83 | TDC175 | 9/99 NMC05 LANL-1707 9/99NMC05000-392 | N/A | N/A | 17 | 10.3 | 1 |
| 18H2 | 2018 | ER Salt | 52 | XBS9409 | 2/99 LANL-88 | N/A | 445 | 16.8 | 1.2 | 0 |
| 18H3 | 2018 | ER Salt | 52 | XBS0C6 | 2/99 LANL-35 080159 | N/A | 328 | 16.8 | 0.9 | 0 |

| Surv # | FY | Chemical Subform | Material Type | Material Name | Hagan SN | SAVY SN | Pu-239 (g) | Container Age (y) | Thermal Power (W) | Corrosion Ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| 18H4 | 2018 | MSE Salt | 52 | XBLS1124 | LANL 120 3/06 03/ 06-05120 | N/A | 110 | 6.2 | 0.45 | 2 |
| 18H5 | 2018 | MgO Crucible | 52 | XBLC6380 | 4/02 A-91 04/ 02-08091 | N/A | 210 | 10.5 | 0.6 | 0 |
| 18H6 | 2018 | DOR Salt | 52 | SLT1802 | 10/99 LANL-1987 8Qt-70 | N/A | 209 | 16 | 0.6 | 1 |
| 18H7 | 2018 | MSE Salt | 52 | XBLSCL4051203 | 8/02 LANL-763 08/ 02-01163 | N/A | 451 | 13 | 6.9 | 3 |
| 18H8 | 2018 | MSE Salt | 52 | XBLSCL1210 | 10/10 LANL-204 10/10-03064 | N/A | 432 | 6 | 6.9 | 0 |
| 19H1 | 2019 | Unalloyed Metal | 42 | GRING18 | NMC03-030412 LANL-2476 | 121103092 | 2165 | 19.4 | 14.9 | 3 |
| 19H3 | 2019 | Incinerator Ash | 83 | TDC153 | NMC08000-318 LANL-442 | N/A | 24.5 | 18.3 | 11.6 | 3 |
| 19H5 | 2019 | MSE Salt | 52 | XBLSCL1606 | 6-00 LANL-180 1QT-180 | 021805118 | 356 | 12.4 | 5.7 | 3 |
| 19H7 | 2019 | Multiple Alloys or Contaminant | 51 | DAS743700 | NMC05000-42 LANL-635 | 051708066 | 679 | 18 | 1.5 | 2 |
| 19IoOP 45 | 2019 | MSE Salt | 56 | XBLS11A | 03-05-05274 LANL-274 | | 143 | 12 | 4.2 | 0 |

| Surv # | FY | Chemical Subform | Material Type | Material Name | Hagan SN | SAVY SN | Pu-239 (g) | Container Age (y) | Thermal Power (W) | Corrosion Ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| 19IoOP 46 | 2019 | MSE Salt | 56 | XBLS6A | 04-02-08270 NUCFIL-013 4-06A-270 | | 154.3 | 13.9 | 4.8 | 1 |
| 19IoOP 50 | 2019 | Multiple Alloys or Contaminant | 51 | DAS743800 | NMCO05000-226 LANL-1501 | | 674 | 18 | 1.5 | 1 |
| 19IoOP 55 | 2019 | MSE Salt | 56 | XBLS5A | 03-06-0531 LANL-351306 | | 105 | 12.7 | 3.2 | 2 |
| 19I0OP 56 | 2019 | MSE Sale | 55 | XBLS4A1 | 03 06-05072 LANL-691 | | 75 | 11.2 | 2.1 | 3 |
| 15S1 | 2015 | Dioxide | 52 | CXLOX08291 1 | N/A | 031105 052 | 786.9 | 3.03 | 2.07 | 0 |
| 15S2 | 2015 | MSE Salt | 52+44 | XBLSCL1217 | N/A | 121103 083 | 178.5 | 1.86 | 2.85 | 0 |
| 15S3 | 2015 | Unalloyed Metal | 53 | XAP6 | N/A | 031105 002 | 69.5 | 3.01 | 0.21 | 0 |
| 15S4 | 2015 | Filter Residue | 52 | ROTRBJ-1C1 | N/A | 031105 051 | 452 | 3.46 | 1.19 | 0 |
| 15S5 | 2015 | MgO | 52 | XBLC9413 | 2/99 LANL-80, 80207 | 041208 055 | 913 | 1.96 | 2.4 | 0 |
| 15S6 | 2015 | Tetra-fluoride | 54 | PHX3F | N/A | 121103 121 | 479.2 | 1.8 | 1.98 | 0 |
| 15S7 | 2015 | Tetra-fluoride | 54 | PHX5R4 | N/A | 121103 052 | 166 | 2.37 | 0.7 | 0 |
| 15S8 | 2015 | MSE Salt | 56+44 | XBLS25 | 10/99 LANL-1932, 80234 | 041208 031 | 430 | 2.55 | 12.4 | 0 |

| Surv # | FY | Chemical Subform | Material Type | Material Name | Hagan SN | SAVY SN | Pu-239 (g) | Container Age (y) | Thermal Power (W) | Corrosion Ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| 15S9 | 2015 | Dioxide | 54 | PBO | N/A | 031105 028 | 1330.8 | 3.57 | 5.5 | 2 |
| 15S10 | 2015 | Dioxide | 56 | RBXS5657-1A | 7/02 LANL-515, 06/02-05305 | 041205 026 | 751 | 2.65 | 3.8 | 2 |
| 16S1 | 2016 | Non-Actinide Metal | 53 | SCRES65B | N/A | 031105 064 | 718 | 4.18 | 2.2 | 0 |
| 16S2 | 2016 | DOR Salt | 52 | SLT1303 | N/A | 041208 034 | 391.9 | 3.08 | 1 | 0 |
| 16S3 | 2016 | Unalloyed Metal | 52 | PMP91308 | N/A | 111308 040 | 3220.6 | 0.84 | 8.5 | 0 |
| 16S4 | 2016 | MSE Salt | 52+44 | XBLSCL1120 A | N/A | 121103 041 | 155.1 | 3.22 | 2.5 | 0 |
| 16S5 | 2016 | Filter Residue | 52 | ROTRB9C3 | N/A | 031105 039 | 500 | 4.87 | 1.3 | 0 |
| 16S6 | 2016 | MSE Salt | 52+44 | XBLSCL1213 | N/A | 021205 021 | 377.03 | 3.24 | 6.03 | 2 |
| 16S7 | 2016 | Unalloyed Metal | 52 | ARIAAQ137 | N/A | 091205 173 | 2456.68 | 3.32 | 6.5 | 0 |
| 16S8 | 2016 | Dioxide | 52+83 | AAP02OX | N/A | 041208 057 | 509.4 | 3.4 | 21.28 | 3 |
| 16S9 | 2016 | MSE Salt | 52+44 | XBLSCL1302 | N/A | 121103 057 | 199.32 | 3.4 | 3.2 | 0 |
| 16S10 | 2016 | MSE Salt | 52+44 | XBLSCL1301 | N/A | 121103 044 | 192.6 | 3.4 | 3.1 | 0 |

| Surv # | FY | Chemical Subform | Material Type | Material Name | Hagan SN | SAVY SN | Pu-239 (g) | Container Age (y) | Thermal Power (W) | Corrosion Ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| 16S11 | 2016 | Dioxide | 52 | CXLOX08291 1 | N/A | 031105 052 | 786.9 | 4.14 | 2.07 | 0 |
| 16S12 | 2016 | Unalloyed Metal | 53 | XAP6 | N/A | 031105 002 | 69.5 | 4.12 | 0.21 | 0 |
| 16S13 | 2016 | Filter Residue | 52 | ROTRBJ-1C1 | N/A | 031105 051 | 452 | 4.58 | 1.19 | 0 |
| 16S14 | 2016 | MSE Salt | 52+44 | XBLSCL1217 | N/A | 121103 083 | 178.5 | 2.96 | 2.85 | 0 |
| 16S15 | 2016 | Dioxide | 83 | GPHS | N/A | 071201 061 | 120 | 2.76 | 60.49 | 0 |
| 17S1 | 2017 | Dioxide | 57 | BLO-39-11-16 | N/A | 111308 080 | 544 | 1.61 | 5 | 2 |
| 17S2 | 2017 | Dioxide | 52 | CXLOX08291 1 | N/A | 031105 052 | 786.9 | 5.16 | 2.07 | 0 |
| 17S3 | 2017 | Unalloyed Metal | 53 | XAP6 | N/A | 031105 002 | 69.5 | 5.15 | 0.21 | 1 |
| 17S4 | 2017 | Filter Residue | 52 | ROTRBJ-1C1 | N/A | 031105 051 | 452 | 5.59 | 1.19 | 1 |
| 17S5 | 2017 | MSE Salt | 52+44 | XBLSCL1217 | N/A | 121103 083 | 178.5 | 3.98 | 2.895 | 1 |
| 17S6 | 2017 | DOR Salt | 52 | SLT1303 | N/A | 111308 050 | 391.9 | 1.03 | 1 | 0 |
| 17S7 | 2017 | Incinerator Ash | 52+54 | INC20602 | N/A | 111103 020 | 31 | 4.67 | 0.1 | 0 |
| 17S8 | 2017 | Unalloyed Metal | 53 | XAP6 (outer) | N/A | 111308 059 | 69.5 | 1.02 | 0.21 | 0 |

| Surv # | FY | Chemical Subform | Material Type | Material Name | Hagan SN | SAVY SN | Pu-239 (g) | Container Age (y) | Thermal Power (W) | Corrosion Ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| 18S1 | 2018 | Compound; Dioxide | 57 | BLO-39-11-16 | N/A | 111308 080 | 544 | 2.4 | 5 | 2 |
| 18S2 | 2018 | Compound Residue | 52 | CXLOX08291 1 | N/A | 031105 052 | 787 | 6.1 | 0.1 | 0 |
| 18S3b | 2018 | Unalloyed Metal | 53 | XAP6 | N/A | 111308 059 | 69 | 2 | 0.21 | 0 |
| 18S4 | 2018 | Dioxide | 52 | ROTRBJ-1C1 | N/A | 031105 051 | 452 | 6.6 | 1.2 | 1 |
| 18S5 | 2018 | MSE Salt | 52 + 44 | XBLSCL1217 | N/A | 121103 083 | 178 | 4.9 | 2.9 | 1 |
| 18S6 | 2018 | DOR Salt | 52 | SLTF3123A | N/A | 121103 062 | 1900 | 5.4 | 2.9 | 1 |
| 18S7 | 2018 | Dioxide | 83 | SAMPCAN2 | N/A | 091205 130 | N/A | 3.8 | 16.6 | 2 |
| 19S1 | 2019 | Dioxide | 57 | BLO-39-11-16 | N/A | 111308 080 | 544 | 3.70 | 5 | 2 |
| 19S2 | 2019 | Dioxide | 52 | CXLOX08291 1 | N/A | 031105 052 | 786.9 | 7.4 | 2.1 | 0 |
| 19S3 | 2019 | MSE Salt | 52+44 | XBLSCL1217 | N/A | 121103 083 | 178.5+10.6 | 6.4 | 2.9 | 1 |
| 19S4 | 2019 | Filter Residue | 52 | ROTRBJ-1C1 | N/A | 031105 051 | 452 | 7.9 | 1.2 | 1 |
| 19S5 | 2019 | Unalloyed Metal | 53 | XAP6 (Outer) | N/A | 111308 059 | 69.5 | 3.46 | 0.2 | 0 |
| 19S6 | 2019 | Unalloyed Metal | 53 | XAP6 (Inner | N/A | 031105 002 | 69.5 | 7.60 | 0.2 | 0 |

| Surv # | FY | Chemical Subform | Material Type | Material Name | Hagan SN | SAVY SN | Pu-239 (g) | Container Age (y) | Thermal Power (W) | Corrosion Ranking |
|---|---|---|---|---|---|---|---|---|---|---|
| 19S9 | 2019 | Sweepings/Screenings | 52 | POX4275C1 | N/A | 091205182 | 1037.4 | 6.4 | 2.7 | 0 |
| 19S10 | 2019 | Salt | 52 | SWPVTB15 | N/A | 111103001 | 678 | 6.5 | 1.8 | 0 |
| 19S11 | 2019 | DOR Salt | 52 | XBSOX153 | N/A | 091205175 | 1079 | 6.4 | 2.8 | 1 |
| 19S13 | 2019 | Dioxide | 56 | RBXS5657-2A | N/A | 081305008 | 2059 | 3.8 | 10.5 | 2 |

Transfer containers are also subject to surveillance activities throughout their maintenance cycle, and although they are not surveillance items "per se" the inspection and test data are documented at the end of each FY. Transfer containers are intended primarily for transfer of nuclear material through the facility and they may be stored for up to one year, at which point the containers must be maintained testing before further use.

Based on all performed maintenance testing results of transfer containers, the Container Management Team has proposed and been granted a new five-year annual lifetime cycle extension when the one-year transfer label expires. The lifecycle extension has been documented in MEMO SPE-2 19:003 and is based on the collected data showing no significant changes of container integrity, o-ring hardness, filter performance and helium leakage rates from the transfer container population. In addition, an annual visual inspection will still be conducted upon the one-year transfer label expiration date. The visual inspection is based on container integrity and the judgment of the Container Management Team per PA-DOP-01080, which includes visual inspection for dents, discoloration, corrosion, functional checks of the closure mechanism and other defects inside and outside of the container that may cause the SAVY 4000 not to function as designed. Notes form the visual inspections and maintenance testing records will continue to be tracked through the current database. After the fifth annual visual inspection cycle, the container will go through the full surveillance testing to ensure all components are still functioning properly. The five-year visual lifetime inspection cycle of the container starts the date of the last recorded maintenance cycle. Table 3 below shows the transfer containers that were visually inspected per MEMO SPE-2 19:003 and passed all visual ques and functional checks while applying a new transfer label upon completion. Due to the way transfer containers are utilized, information about contents, dates of packaging, etc., is not recorded.

**Table 3. Transfer containers visually inspected in FY19.**

| Transfer Container Sample Number | SAVY 4000 Serial Number | Date of Transfer Container Creation | Age at Annual Visual Inspection (~years) | Number of Visual Inspection's remaining till 5 year maintenance testing |
|---|---|---|---|---|
| **1T** | 111603055 B/L | 8/3/17 | 1.8 | 3 |
| **2T** | 071201073 B/L | 3/25/15 | 4.2 | 1 |
| **3T** | 071201137 B/L | 6/8/15 | 4.0 | 1 |
| **4T** | 031403108 B/L | 1/29/16 | 3.3 | 2 |
| **5T** | 031403033 B/L | 9/10/15 | 3.7 | 1 |
| **6T** | 091205158B/091205132L | 6/20/16 | 3.0 | 2 |
| **7T** | 021803062 B/L | 8/24/18 | 1.0 | 4 |
| **8T** | 021803021 B/L | 8/24/18 | 1.0 | 4 |
| **9T** | 111603058 B/L | 8/2/17 | 2.0 | 3 |
| **10T** | 111603074 B/L | 8/3/17 | 2.0 | 3 |
| **11T** | 071701112 B/L | 4/10/18 | 1.4 | 4 |

| | | | | |
|---|---|---|---|---|
| **12T** | 011701145 B/L | 8/16/18 | 1.1 | 4 |
| **13T** | 081305013 B/L | 9/10/15 | 4.0 | 4 |
| **14T** | 011705040 B/L | 9/28/16 | 3.0 | 4 |
| **15T** | 081305092 B/L | 3/25/15 | 4.5 | 4 |
| **16T** | 111608072 B/L | 3/16/16 | 3.5 | 3 |
| **17T** | 031403054 B/L | 3/16/16 | 3.5 | 4 |
| **18T** | 021803057 B/L | 3/30/16 | 3.5 | 4 |
| **19T** | 111603119 B/L | 3/25/15 | 4.5 | 4 |

# 4 Results

## 4.1 Hagan Containers

Surveillance was performed on 9 Hagan storage containers in FY19. The surveillance test results are given in Table 4. Five of the nine containers had completed unpacking data forms. Where it is noted the unpacking data presented is derived from photographs and the container integrity inspection form (where available). Three of the Hagan containers were introduced into the glovebox line due to the concern of a having failed bag-out bag. Six of the Hagan containers had the filter particle penetration, filter pressure drop, O-ring durometer, water penetration and the helium leakage tests performed. The surveillance results are presented below.

### *4.1.1 Visual Inspections*

Corrosion was observed in eight of the nine Hagan containers that had surveillance performed in FY19.

Container 19H1 packaged with an unalloyed metal item had heavy corrosion on the inside surfaces of the container from the degradation of PVC bag. Container 19H3 packaged with a Pu-238 incinerator ash item had areas of general corrosion likely from the degradation of the PVC bag. Container 19H5 packaged with an MSE Salt could not be opened and had to be introduced in the glove box line to be cut open, which indicate that corrosive gases had escaped through the sealing surfaces. Once the container was cut opened, dry general corrosion was covering all of the inside surfaces. Container 19H7 had areas of heavy corrosion, but the corrosion observed did not cover the entire container leaving areas of native metal that was not affected by the corrosive environment. Container 19IoOP45 showed some signs of PVC bag degradation, but no corrosion was observed. Container 19IoOP46 had white residue over the inner surfaces and the small amount of corrosion observed did not extend past the o-ring seal. Container 19IoOP50 show a small amount of corrosion and bag-out bag residue was observed on the bottom of the container. The most significant observation for this container is how it compared to 19H7, a near matched item and package, in that did not have the level of corrosion that was seen in 19H7. Container 19IoOP55 contained an MSE Salt and did showed signs of corrosion. Container 19IoOP56 had general corrosion and areas of heavier corrosion along with signs of bag-out bag degradation.

Table 4. Surveillance test results for Hagan storage containers.

| ID | Container Serial No. and Size | Container Visual Inspection | Corrosion Ranking | O-Ring Visual Inspection | Material Name and IDC | Sample Power (W) | Package Age (y) | Filter Particle Penetration (%) ± 0.0002 | Filter Pressure Drop (in W.C) ± 0.02 | Helium Leakage Rate $(\frac{atm-cc}{s})$ | O-ring Durometer (Shore M) ± 2.15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19H1 | NMC03-030412 LANL-2476<br><br>3 Quart | Contaminated Hagan, more than one bag-out bag, Conflat inner | 3 | Not performed | GRING18<br><br>M44 | 14.9 | 19.4 | NM | NM | NM | NM |
| 19H3 | NMC08000-318 LANL-442<br><br>8 Quart | It is unclear if the corrosion observed on the threads of the Hagan lid was present when the container was closed in the vault. This item was documented after being in a processing line for a period of time. | 3 | Not performed | TDC153<br><br>R47 | 11.6 | 18.3 | NM | NM | NM | NM |

| ID | Container Serial No. and Size | Container Visual Inspection | Corrosion Ranking | O-Ring Visual Inspection | Material Name and IDC | Sample Power (W) | Package Age (y) | Filter Particle Penetration (%) ± 0.0002 | Filter Pressure Drop (in W.C) ± 0.02 | Helium Leakage Rate $(\frac{atm-cc}{s})$ | O-ring Durometer (Shore M) ± 2.15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19H5 | 6-00 LANL-180 1QT-180<br>1 Quart | This container had to be cut open because the lid would not turn. | 3 | Not performed | XBLSCL1606<br>R83 | 5.7 | 12.4 | NM | NM | NM | NM |
| 19H7 | NMC05000-42 LANL-635<br>5 Quart | There is extensive corrosion throughout the inside of the container but it does not pass the o-ring seal. Small white powder is seen in the outside of the filter | 2 | Not comments | DAS743700<br>M74 | 4.4 | 18 | 0.0001 | 0.858 | 1.30E-06 | 76.8 |
| 19IoOP45 | 03-05-05274 LANL-274<br>5 Quart | Some signs of smearing from bag-out bag inside not major | 0 | Not comments | XBL11A<br>R83 | 4.4 | 12 | 0.0127 | 0.506 | 7.10E-06 | 78.7 |

| ID | Container Serial No. and Size | Container Visual Inspection | Corrosion Ranking | O-Ring Visual Inspection | Material Name and IDC | Sample Power (W) | Package Age (y) | Filter Particle Penetration (%) ± 0.0002 | Filter Pressure Drop (in W.C) ± 0.02 | Helium Leakage Rate ($\frac{atm-cc}{s}$) | O-ring Durometer (Shore M) ± 2.15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19IoOP46 | 04-02-08270 NUCFIL-013 4-06A-270<br>8 Quart | White residue throughout the interior of container and residue powder at the bottom of container | 1 | No comments | XBLS6A<br>R83 | 4.8 | 13.9 | 0.0001 | 0.431 | 1.20E-07 | 77.3 |

| ID | Container Serial No. and Size | Container Visual Inspection | Corrosion Ranking | O-Ring Visual Inspection | Material Name and IDC | Sample Power (W) | Package Age (y) | Filter Particle Penetration (%) ± 0.0002 | Filter Pressure Drop (in W.C) ± 0.02 | Helium Leakage Rate ($\frac{atm-cc}{s}$) | O-ring Durometer (Shore M) ± 2.15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19IoOP50 | NMCO05000-226 LANL-1501<br><br>5 Quart | There is some residue left over from the inner package where it made contact with the container. This residue does have corrosion with it, there is also some corrosion on the collar weld and where the TID spine is elded. The other portions of the inside are clean with no corrosion. | 1 | Not performed | DAS743800<br><br>M74 | 1.5 | 18 | 0.0066 | 0.821 | 1.10E-07 | 77.8 |

| ID | Container Serial No. and Size | Container Visual Inspection | Corrosion Ranking | O-Ring Visual Inspection | Material Name and IDC | Sample Power (W) | Package Age (y) | Filter Particle Penetration (%) ± 0.0002 | Filter Pressure Drop (in W.C) ± 0.02 | Helium Leakage Rate ($\frac{atm-cc}{s}$) | O-ring Durometer (Shore M) ± 2.15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19IoOP55 | 03-06-0531 LANL-351306<br><br>5 Quart | There is corrosion throughout the inside of the container, the corrosion does not pass the o-ring seal. There is also some small traces of white powder outside the filter. | 2 | No comments | XBLS5A<br><br>R83 | 3.2 | 12.7 | 0.007 | 0.551 | 1.40E-07 | 77.8 |

| ID | Container Serial No. and Size | Container Visual Inspection | Corrosion Ranking | O-Ring Visual Inspection | Material Name and IDC | Sample Power (W) | Package Age (y) | Filter Particle Penetration (%) ± 0.0002 | Filter Pressure Drop (in W.C) ± 0.02 | Helium Leakage Rate ($\frac{atm-cc}{s}$) | O-ring Durometer (Shore M) ± 2.15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19IoOP56 | 03 06-05072 LANL-691<br>5 Quart | This container is severely corroded with general corrosion completely covering the interior of the container. The exterior side of the filter shows corrosion and small traces of white powder. | 3 | No Comments | XBLS4A1<br>R83 | 2.1 | 11.2 | 0.0104 | 0.701 | 4.00E-05 | 78.6 |

#### 4.1.1.1 Hagan Container, Surveillance, Sample #19H1, NMC03-030412 LANL-2476, GRING18, MT42, 2165 g Pu, M44, Metal; Unalloyed Metal, 14.9 W, 19.4 years

Container 19H1 was packaged with MT42 (Pu-242) an unalloyed metal item. The material was packaged inside of a conflat container. The conflat container was packaged inside two layers of bags (the innermost bag was a PVC bag-out bag and the outer most was a non-PVC bag). Photographs were taken in lieu of the formal visual inspection and are shown in Figure 4-1 The inner surfaces of the Hagan were heavily corroded, likely from the degradation of the PVC bag. There was corrosion product seen in the bottom of the Hagan. A decision was made to place the container and its contents into the glove box line for radiological control. From the photos collected on the day of unpacking it appears that the corrosive gasses were able to affect the threaded area of the Hagan indicating that the Hagan seal was compromised.

**Table 5. Unpacking data for Sample 19H1 (based on photographs and filled out unpack form)**

| Surveillance sample number | 19H1 |
|---|---|
| Person performing the repack | Kennard Wilson |
| Date of Unloading | 8/7/19 |
| SAVY 4000 or Hagan Serial #'s: | Body: |
| | Lid: NMC03-030412_LANL-2476 |
| Overall Package Weight Before Unloading: | 6936.5g |
| Outer Container Condition: | Not noted |
| Pewter Outer Shielding present? | No |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No, but high rad |
| O-ring installed? | Yes (photo) |
| Pewter Internal shielding present? | Not noted |
| Condition? | Inner bag discolored w/ another bag around it (photo) |
| Any liquid observed inside/outside the bag-out-bag? | No, but there is a bit of bag residue at the bottom of the container |
| Type of inner container: | Conflat |
| Item content verification: | No |
| Condition of inner container? | Not noted |
| Will bag-out bag be replaced before re-pack? | Yes |
| Will inner container be replaced before re-pack? | Not noted |
| Overall package weight after repack: | Not Noted |
| Comments: | No comments |


**Figure 4-1 Visual inspection of 19H1. (A) Heavily degraded bag-out bag inside of non-PVC bag. (B) Deposits of corrosion products and evidence of bag-out bag residue. (C) Corrosion in the thread region of the Hagan clearly past the o-ring seal. (D) Heavy deposits of bag-out bag material.**

#### *4.1.1.2 Hagan Container, Surveillance, Sample #19H3, NMC08000-318 LANL-442, TDC153, MT83, 24.5 g Pu, R47, Incinerator Ash, 11.6 W, 18.3 years*

Container 19H3 was packaged with MT83 incinerator ash. This container had already been introduced before the container management team was aware that it was being processed, therefore it is unclear of the packaging configuration while it was in storage. Although the container had been in the glove box line for some time it is assumed to have had corrosion before being introduced.

Due to the container being introduced into the glove box photographs were taken in lieu of the formal visual inspection. Based on the photographs, there were no visible signs that the exterior of the container was corroded or that the container was not properly sealed.

**Table 6. Unpacking data for Sample 19H3 (based on photographs)**

| Surveillance sample number | 19H3 |
|---|---|
| Person performing the repack | Unknown |
| Date of Unloading | Unknown |
| SAVY 4000 or Hagan Serial #'s: | Body: 05/99NMC08000-318<br>Lid: 4/99 LANL-442 |
| Overall Package Weight Before Unloading: | Not measured |
| Outer Container Condition: | Good (photo) |
| Pewter Outer Shielding present? | Unknown |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | Unknown |
| O-ring installed? | Yes (photo) |
| Pewter Internal shielding present? | Not noted |
| Condition? | Unknown |
| Any liquid observed inside/outside the bag-out-bag? | Not at the time photos were taken |
| Type of inner container: | Unknown |
| Item content verification: | TDC153 (photo) |
| Condition of inner container? | Unknown |
| Will bag-out bag be replaced before re-pack? | Yes |
| Will inner container be replaced before re-pack? | Unknown |
| Overall package weight after repack: | Unknown |
| Comments: | No comments |


**Figure 4-2 Visual inspection of 19H3 (A) Corrosion on inner surface of Hagan container. (B) Corrosion on the underside of the Hagan lid.**

#### 4.1.1.3 Hagan Container, Surveillance, Sample #19H5, 6-00 LANL-180 1QT-180, XBLSCL1606, MT52, 356 g Pu, R83, MSE Salt , 5.7 W, 12.4 years

Container 19H5 was packaged with MT52 MSE salt. The material was packaged inside of a taped slip lid container. The slip lid container was packaged inside a single PVC bag-out bag. The bagged container was packaged inside the 1-Qt Hagan container without shielding.

The Hagan container was introduced into the glovebox line due to the lid being seized on the Hagan body. Photographs were taken in lieu of the formal visual inspection. Based on the photographs, there were no visible signs that the exterior of the container was corroded or that the container was not properly sealed. Some white residue was observed around the filter prior the container being introduced into the glove box line. Once 19H5 was cut open there was evidence that the seal was compromised based on corrosion being present on the threads past the o-ring seal (Figure 4-4). Dry green powder was seen on the inner surfaces (Figure 4-3). The inside surfaces of the container were completely covered by a dry residue ranging in color from green to brown (Figure 4 3 B, C).

**Table 7. Unpacking data for Sample 19H5 (based on photographs)**

| Surveillance sample number | 19H5 |
|---|---|
| Person performing the repack | Kennard Wilson |
| Date of Unloading | 4/16/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 6-00 LANL-180 |
| | Lid: 1QT-180 |
| Overall Package Weight Before Unloading: | Not measured |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | No |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | Unknown |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | No |
| Condition? | Opaque white and degraded |
| Any liquid observed inside/outside the bag-out-bag? | No |
| Type of inner container: | Taped slip lid |
| Item content verification: | XBLSCL1606 (photo) |
| Condition of inner container? | Unknown |
| Will bag-out bag be replaced before re-pack? | Yes |
| Will inner container be replaced before re-pack? | Unknown |
| Overall package weight after repack: | Unknown |
| Comments: | No comments |

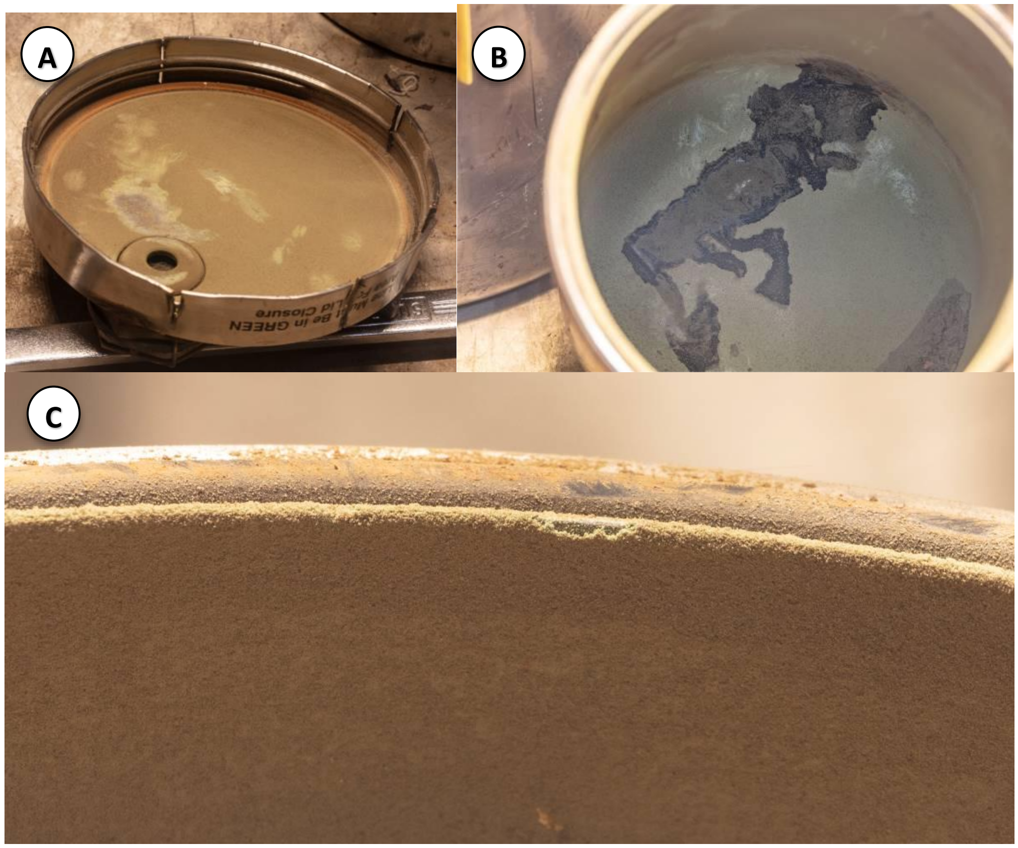



**Figure 4-3. Photographs of 19H5 after it was opened inside of glovebox. (A) Internal surfaces of container 19H5 lid showing dry brown residue (B) Bag-out bag residue covering inside surface of the body.**

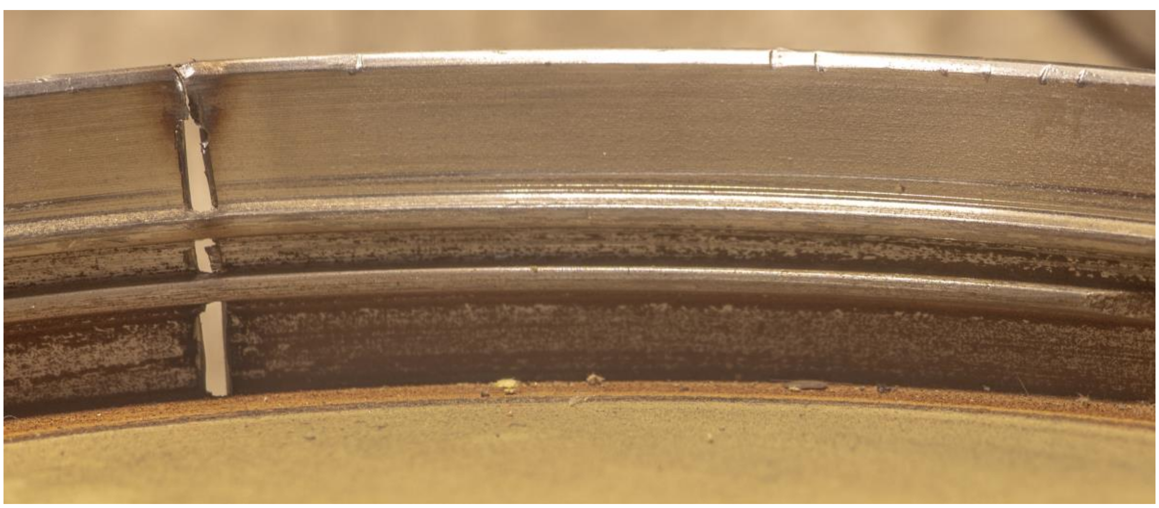


**Figure 4-4. Image of 19H5 showing corrosion on threads.**

The powder was removed from the container by brushing. The container was weighed before and after brushing and showed a weight difference of 4.2 grams due to removal of the powder. The identity of the powder was not determined but is believed to be mixture of stainless steel corrosion product and degradation product of the PVC bag. A section was removed from the sidewall for examination. The container parts were cleaned by wiping with DI water. Optical microscopy was performed on sections of the cleaned container lid and body. The lid shows mostly general corrosion and shallow pits. The pit depths (and diameters) could not be determined because much of the native surface was removed.

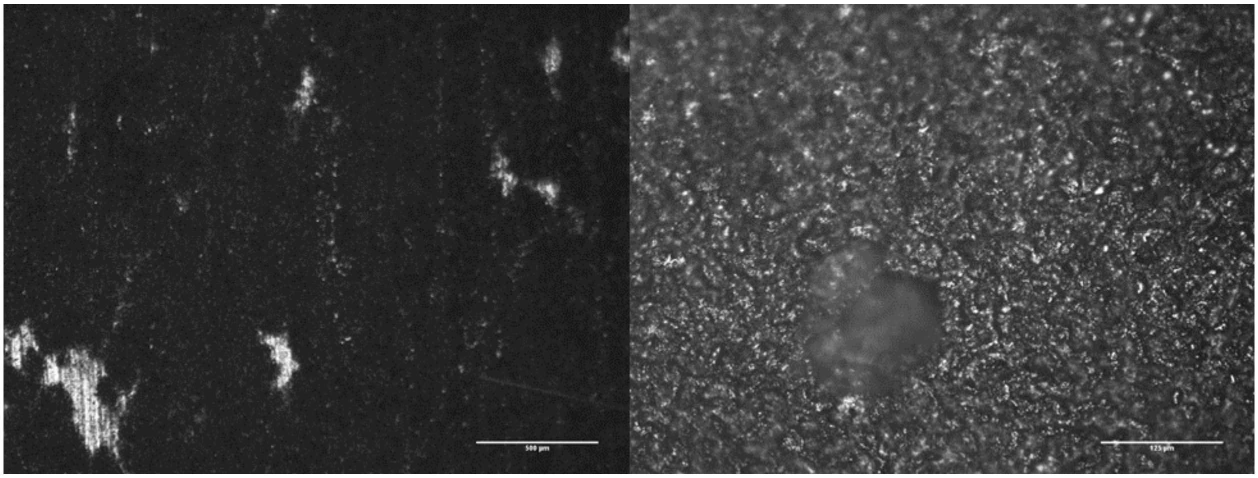


**Figure 4-5 Hagan container 19H5 showing general corrosion and pitting on the lid (left) and sidewall (right)**

#### 4.1.1.4 Hagan Container, Surveillance, Sample #19H7, LANL 120 3/06NMC05000-42 LANL-635, DAS743700, MT51, 679 g Pu, M74, Alloyed Metal , 1.5 W, 18 years

Container 19H7 was packaged with MT51 alloyed metal. The material was packaged inside of a taped slip lid container. The slip lid container was packaged inside a single PVC bag-out bag with an additional non-PVC bag around it (Figure 4-6 C, D). The bagged container was packaged inside the 5-Qt Hagan container with outer shielding and no outer shielding.

The Hagan was identified in an inventory for having white residue around the filter so it was added to the FY19 surveillance plan [1]. A nearly identical item and configuration (19IoOP50) was identified, but did not show the same signs that 19H7 did.

Corrosion was found on large portions of the inside surfaces of the Hagan container (Figure 4-6 A). The Hagan lid also has corrosion distributed across most of the inside surface of the container lid (Figure 4-6 B). The inner container appears to have corrosion on it’s exterior surfaces (Figure 4-6 D).

**Table 8. Unpacking data for Sample 19H7**

| Surveillance sample number | 19H7 |
|---|---|
| Person performing the repack | Dung Vu |
| Date of Unloading | 7/30/2019 |
| SAVY 4000 or Hagan Serial #’s: | Body: 05/99 NMCO50000-042<br>Lid: NMC-05; LANL-635, NucFil-013 |
| Overall Package Weight Before Unloading: | Not measured |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | No |
| Condition? | good |
| Any liquid observed inside/outside the bag-out-bag? | No |
| Type of inner container: | Taped slip lid |
| Item content verification: | DAS743700 |
| Condition of inner container? | Corroded |
| Will bag-out bag be replaced before re-pack? | Yes |
| Will inner container be replaced before re-pack? | Yes |
| Overall package weight after repack: | Not measured |
| Comments: | No comments |

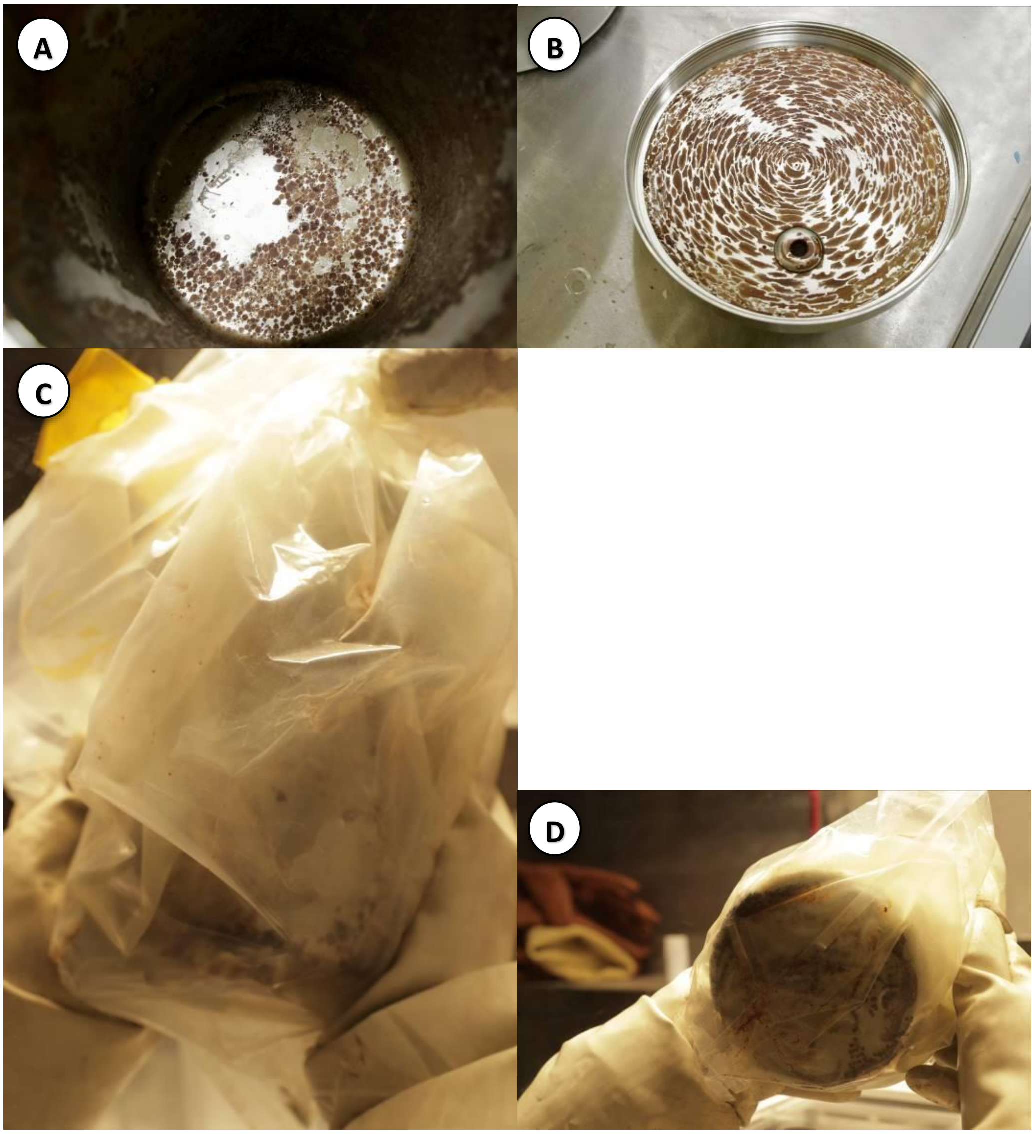



**Figure 4-6 Visual inspection of 19H7 (A) Corrosion on inner surface of Hagan container. (B) Corrosion on the underside of the Hagan lid. (C) Non-PVC bag around inner container. (D) Evidence of corrosion on inner container surfaces.**

#### 4.1.1.5 Hagan Container, Item of Opportunity, Sample #19IoOP45, 03-05-05274 LANL-274, XBLS11A, MT56, 143 g Pu, R83, MSE Salt , 4.2 W, 12 years

Container 19IoOP45 was packaged with MT56 MSE Salt. The material was packaged inside of a taped slip lid container (Figure 4-7 B). The slip lid container was packaged inside a single PVC bag-out bag. The bagged container was packaged inside the 5-Qt Hagan container with external pewter shielding.

Traces of bag residue was found on the inside of the Hagan, but no corrosion was identified (Figure 4-7 A). A small amount of corrosion can be seen on the exterior surfaces of the inner container (Figure 4-7 B)

**Table 9. Unpacking data for Sample 19IoOP45 (based on photographs)**

| Surveillance sample number | 19IoOP45 |
|---|---|
| Person performing the repack | Brandon Williams |
| Date of Unloading | 8/01/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 03/06-05274 |
| | Lid: 3/06 LANL-274 |
| Overall Package Weight Before Unloading: | 6941.2 g |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes (photo) |
| Pewter Internal shielding present? | Unknown |
| Condition? | Bag has slight discoloring |
| Any liquid observed inside/outside the bag-out-bag? | No |
| Type of inner container: | Taped slip lid |
| Item content verification: | XBLS11A |
| Condition of inner container? | Good |
| Will bag-out bag be replaced before re-pack? | No |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not measured |
| Comments: | No comments |

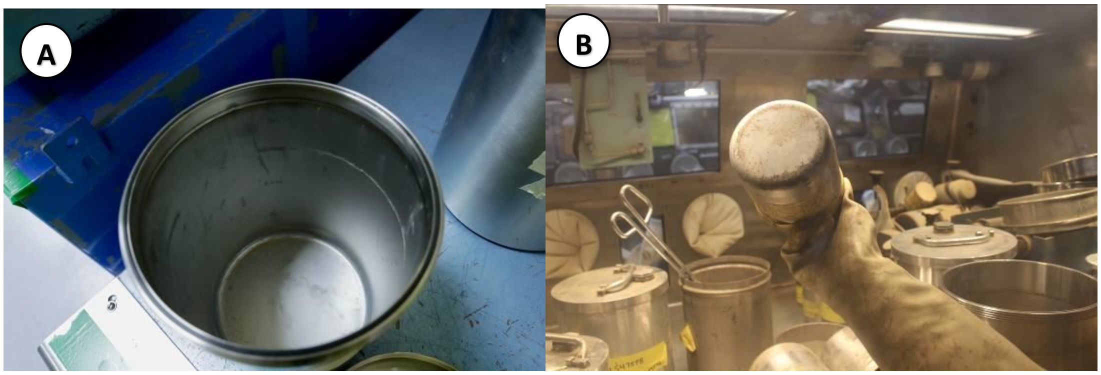



**Figure 4-7 Visual inspection of 19IoOP45 (A) No evidence of corrosion on the inner surfaces of Hagan 19IoOP45. (B) Lite corrosion on inner container.**

#### 4.1.1.6 Hagan Container, Item of Opportunity, Sample #19IoOP46, 04/02-08270 4/06 A-270, XBLS6A, MT56, 154.3 g Pu, R83, MSE Salt, 4.8 W, 13.9 years

Container 19IoOP46 was packaged with MT56 MSE Salt. The inside surfaces of the Hagan were contamination free. The container had a strong chlorine smell when opened. Small, isolated spots of corrosion were found on the sidewall, and staining was found on the container bottom. The bag-out bag was heavily degraded and appeared to be brittle (Figure 4-8 C). The inner container had bag material adhered to it and seemed to be corroding. The O-ring was inspected, and no issues were identified.

**Table 10. Unpacking data for Sample 19IoOP46**

| Surveillance sample number | 19IoOP46 |
|---|---|
| Person performing the repack | Brandon Williams |
| Date of Unloading | 8/01/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 04/02-08270 |
| | Lid: 4/06 A-270 |
| Overall Package Weight Before Unloading: | 7937.9 g |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | No |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes (photo) |
| Pewter Internal shielding present? | Unknown |
| Condition? | Discolored and brittle (photo) |
| Any liquid observed inside/outside the bag-out-bag? | No |
| Type of inner container: | Taped slip lid |
| Item content verification: | XBLS6AA |
| Condition of inner container? | Bag residue and corrosion on outer surfaces of inner container (photo) |
| Will bag-out bag be replaced before re-pack? | No |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not |
| Comments: | No comments |

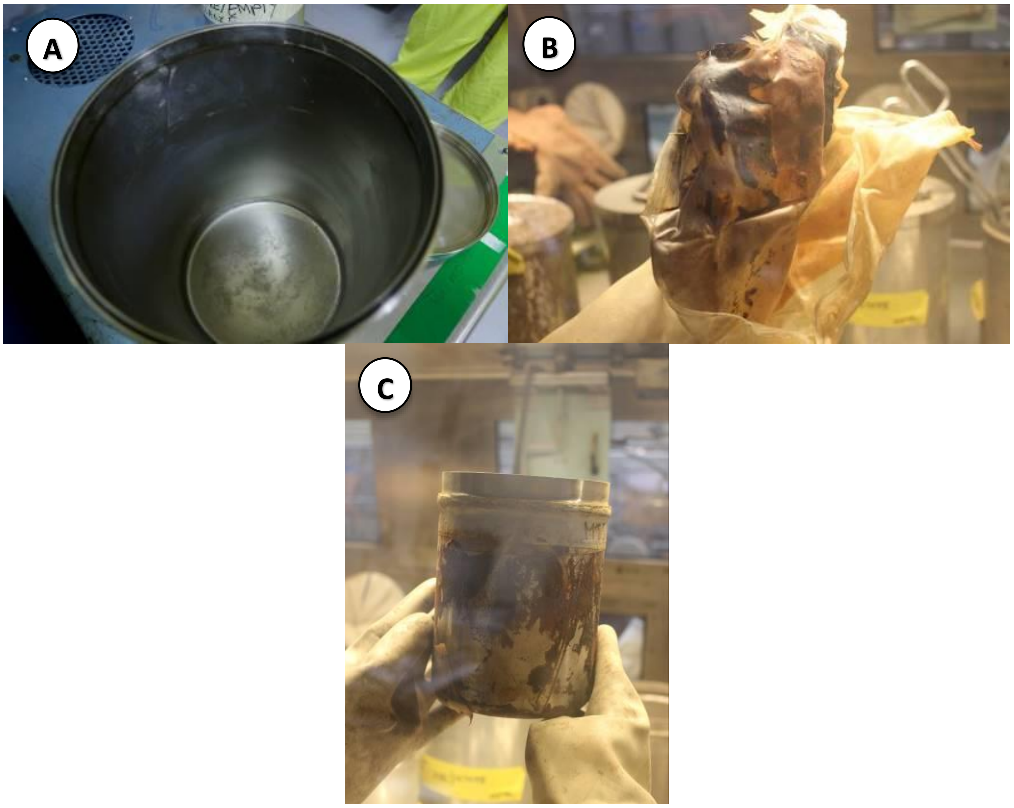



**Figure 4-8 Visual inspection of 19IoOP46 (A) No evidence of corrosion on the inner surfaces of Hagan 19IoOP46. (B) Bag material has degraded and is beginning to become brittle. (C) Inner container is showing signs of corrosion.**

#### *4.1.1.7 Hagan Container, Item of Opportunity, Sample#19IoOP50, 9/99 NMCO50000-226; PR2447657 NMC-05; LANL-1501, NucFil-013, DAS743800, MT51, 674 g Pu, M74, Metal;Multiple Alloys or Contaminant, 1.5 W, 18 years*

Container 19IoOP50 was packaged with MT51 Multiple Alloys or Contaminants. The material was packaged inside of a taped slip lid container. The slip lid container was packaged inside a single PVC bag-out bag with an additional non-PVC bag around it (Figure 4-9 B). The bagged container was packaged inside the Hagan container with outer pewter shielding.

A small amount of corrosion was observed at the bottom of 19IoOP50 (Figure 4-9 A). In comparison to the other like item, 19H7, it has considerable less corrosion. This difference cannot currently be explained but the surveillance plan is working to address possible environmental variables.

**Table 11. Unpacking data for Sample 19IoOP50**

| Surveillance sample number | 19IoOP50 |
|---|---|
| Person performing the repack | Dung Vu |
| Date of Unloading | 7/30/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 9/99 NMCO50000-226; PR2447657<br>Lid: NMC-05; LANL-1501, NucFil-013 |
| Overall Package Weight Before Unloading: | Not measured g |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | No |
| Condition? | Good bag |
| Any liquid observed inside/outside the bag-out-bag? | No |
| Type of inner container: | Taped slip lid |
| Item content verification: | DAS743800 |
| Condition of inner container? | Corroded; The inside of the inner container was completely rusted. The outside show some rust throughout |
| Will bag-out bag be replaced before re-pack? | Yes |
| Will inner container be replaced before re-pack? | Yes |
| Overall package weight after repack: | Not measured |
| Comments: | No comments |

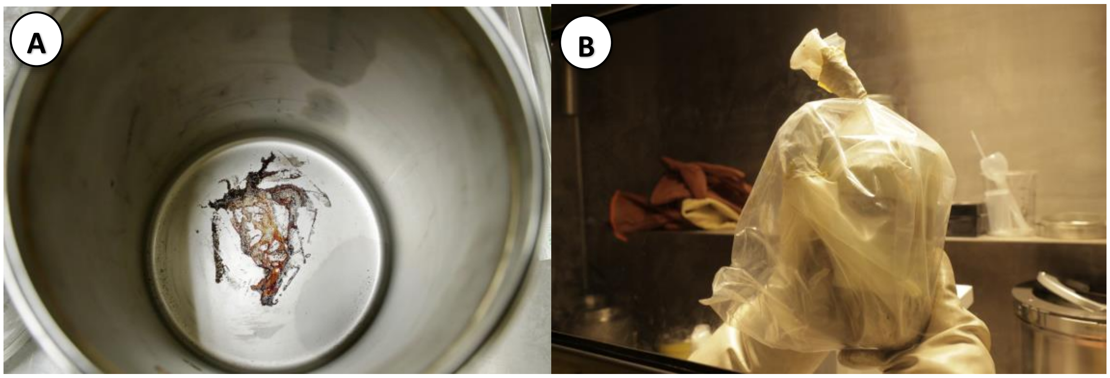



**Figure 4-9 Visual inspection results of 19IoOP50 during unpacking. (A) Residue found at the bottom of 19IoOP50 from bag-out bag. (B) Non-PVC bag around PVC bag-out bag.**

#### 4.1.1.8 Hagan Container, Item of Opportunity, Sample#19IoOP55, 03/06-05351 3/06 LANL-351, XBLS5A, MT56, 105 g Pu, R83, MSE Salt, 3.2 W, 12.7 years

Container 19IoOP55 was packaged with MT56 MSE Salt. The material was packaged inside of a taped slip lid container. The slip lid container was packaged inside a single PVC bag-out bag. The bagged container was packaged directly inside the Hagan container. It is not clear whether or not the Hagan had outer shielding.

The inner surfaces of 19IoOP55 had areas of corrosion throughout the inner surfaces (Figure 4-10 A). Areas of heavy corrosion were present near the weld region of the body and at the bottom of the body. The bag material was heavily discolored (Figure 4-10 B). The inner slip top container also had corrosion and bag residue on the outer surfaces (Figure 4-10 C).

**Table 12. Unpacking data for Sample 19IoOPa (from photographs)**

| Surveillance sample number | 19IoOP55 |
|---|---|
| Person performing the repack | Brandon Williams |
| Date of Unloading | 7/23/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 03/06-05351 |
| | Lid: 3/06 LANL-351 |
| Overall Package Weight Before Unloading: | 5955 g |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | Unknown |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes (photo) |
| Pewter Internal shielding present? | Unknown |
| Condition? | Bag was discolored, but looks pliable (photo) |
| Any liquid observed inside/outside the bag-out-bag? | No |
| Type of inner container: | Taped slip lid |
| Item content verification: | XBLS5A |
| Condition of inner container? | Some corrosion with degraded bag material adhered to the outer surfaces |
| Will bag-out bag be replaced before re-pack? | No |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not measured |
| Comments: | No comments |


**Figure 4-10 Visual inspection results of 19IoOP55 during unpacking. (A) Residue found at the bottom of 19IoOP55 from bag-out bag. (B) Bag-out bag is showing signs of degradation and has turned dark. (C) Signs of corrosion and evidence of bag residue on inner container.**

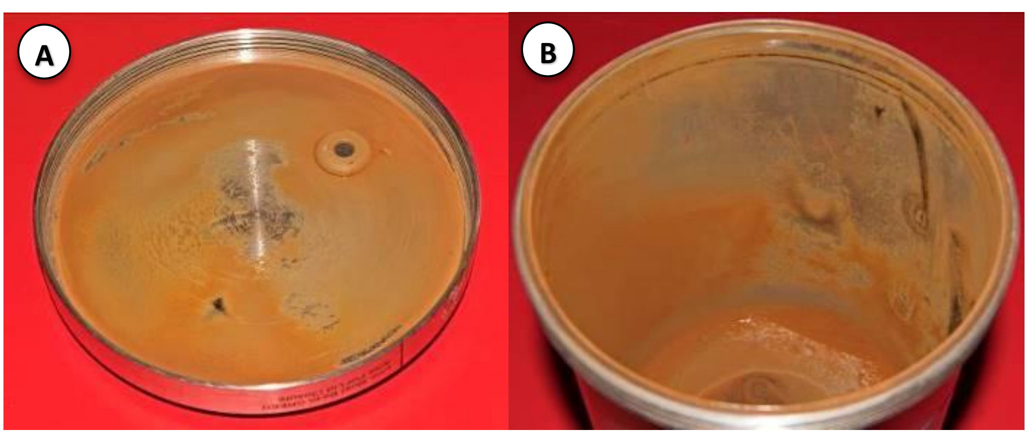
#### *4.1.1.9 Hagan Container, Item of Opportunity, Sample#19IoOP56, 03/06-05072 5/99 LANL-691, XBLS4A1, MT55, 75 g Pu, R83, MSE Salt, 2.1 W, 11.2 years*

Container 19IoOP56 was packaged with MT55 MSE Salt. The material was packaged inside of a taped slip lid container. The slip lid container was packaged inside a single PVC bag-out bag. The bagged container was packaged directly inside the Hagan container. It is not clear whether or not the Hagan had outer shielding.

Heavy general corrosion can be seen on the inner surfaces of 19IoOP (Figure 4-11 A, B). The bag from 19IoOP56 was heavily discolored and degraded (Figure 4-11 C). Corrosion was found on the inner container along with bag-out bag residue (Figure 4-11 D). This container did fail the helium leakage rate test with a leakage rate of $4.00 \times 10^{-8}$. The reason for the failing leakage test is still under investigation.

**Table 13. Unpacking data for Sample 19IoOP56**

| Surveillance sample number | 19IoOP56 |
|---|---|
| Person performing the repack | Ron Chavez |
| Date of Unloading | 8/01/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 03/06-05072<br>Lid: 5/99 LANL-691 |
| Overall Package Weight Before Unloading: | 5494.3 g |
| Outer Container Condition: | Corroded |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes (photo) |
| Pewter Internal shielding present? | No |
| Condition? | Brittle |
| Any liquid observed inside/outside the bag-out-bag? | No (photo) |
| Type of inner container: | Taped slip lid |
| Item content verification: | XBLS4A1 |
| Condition of inner container? | Corrosion with heavy amounts of degraded bag material adhered to the outer surfaces |
| Will bag-out bag be replaced before re-pack? | No |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not measured |
| Comments: | Rust in filter and threads |



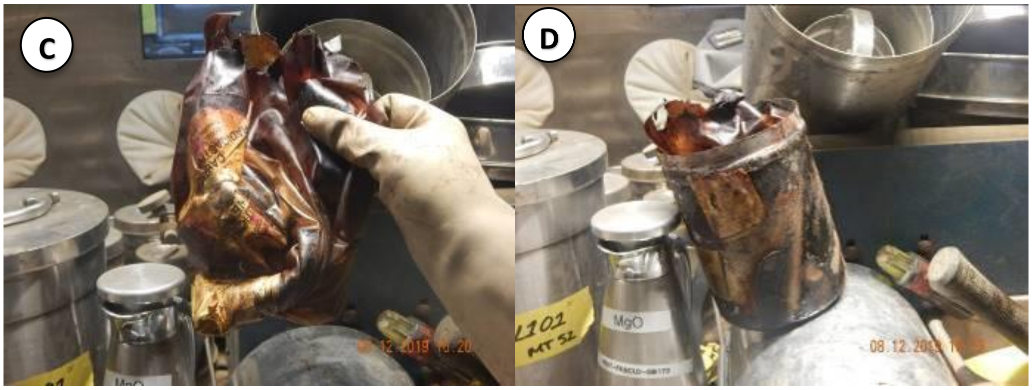



**Figure 4-11 Visual inspection results of 19IoOP56 during unpacking. (A) General corrosion on the lid of 19IoOP56. (B) General corrosion on the body of 19IoOP56. (C) Heavily discolored and degrades bag-out bag from 19IoOP56. (D) Condition of inner container with corrosion.**

### *4.1.2 O-Ring Tests*

#### *4.1.2.1 Visual Inspection of the O-rings*

Visual inspections were performed on the O-rings for containers 19H7, 19IoOP45, 19IoOP46, 19IoOP50, 19IoOP55 and 19IoOP56. No issues were identified in the inspection.

#### *4.1.2.2 Leakage Rate Tests*

The leakage rate results for the Hagan storage containers are shown in Figure 4-12 for all Hagan containers measured in FY15 through FY19. The measured leakage rates are shown in atm-cc/s of helium at 75 Torr into vacuum. One O-ring failed the leakage test each in FY17, FY18 and FY, with a measurement above the failure criterion of $1 \times 10^{-5}$ atm cc/s, possibly resulting from the O-ring hardness being out of specification or the amount of compression set. Due to the Hagan's design and lack of historic data on o-ring thicknesses, it is not possible to acquire a compression set measurement. Because the Hagan is designed with a threaded lid that can be closed to different degrees, it makes it difficult to determine what the gland size is for each container.

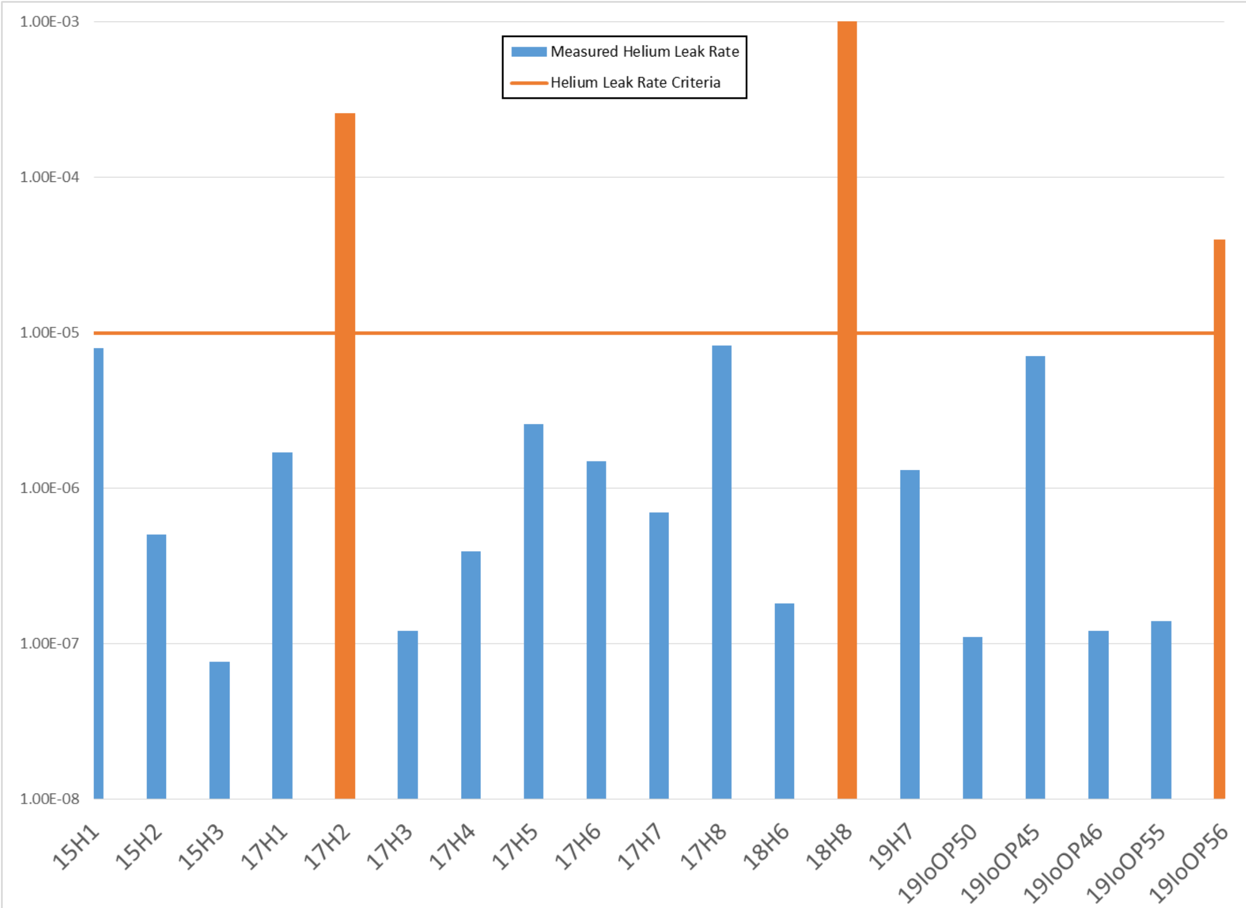



**Figure 4-12. Leakage rates measured for each Hagan container from FY15 to FY19. The red line shows the failure criteria. One container failed each in FY17, FY18 and FY19 (orange bars). Values on y-axis are in atmcc/sec.**

### *4.1.2.3 O-ring Hardness Tests*

The two Hagan O-rings tested in FY18 had hardness values of 79.9 and 80.1 durometer units, respectively. The O-ring from container 18H8 exceeded the specification limit of 80.0 durometer units. The FY18 hardness measurements are shown in Figure 4-13 as orange bars and compared with the FY16 and FY17 results (blue bars). The O-ring hardness for FY16 through FY18 containers ranged from 75.2 to 81.8 and had an average of 79.2 durometer units. The population of 20 O-rings used as a baseline in the lifetime extension studies have a hardness of 76.8 ±6.07 durometer units, with a maximum of 78.6 and a minimum of 73.9 durometer units. These baseline O-ring measurements were performed on unused Hagan O-rings that had been stored in plastic bags.

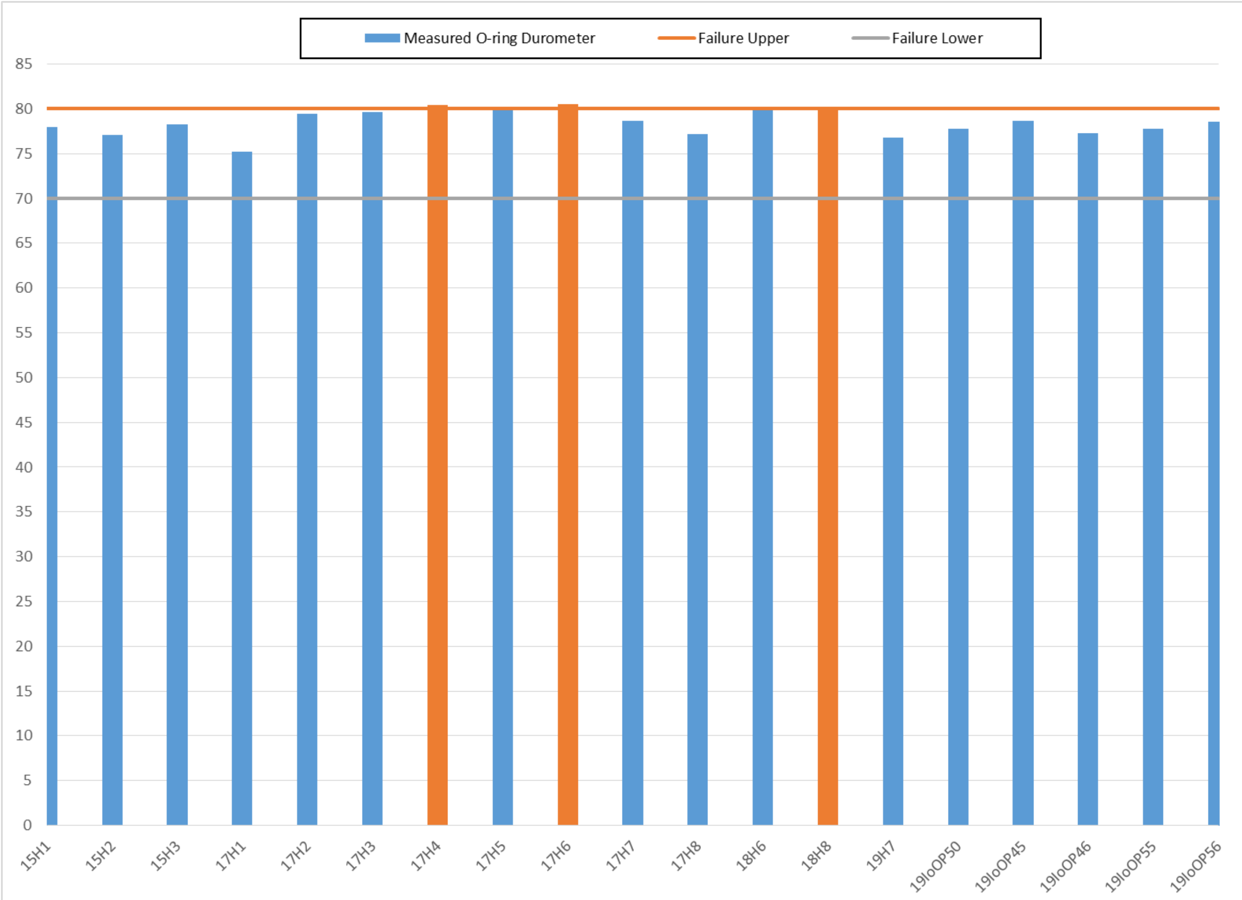



**Figure 4-13. Durometer measurements for each Hagan container from FY15 to FY19. The red and silver lines represent the lower and upper bounds for the hardness, respectively. Two o-rings from FY17 and 1 o-ring from FY18 failed the hardness criteria (orange bars) The O-ring durometer values on the y-axis are Shore-M hardness values.**

### *4.1.3 Filter Tests*

#### 4.1.3.1 Particle Penetration

The aerosol data are reported as a percent penetration, also known as the percent leakage. Six Hagan containers were particle penetration tested in FY19 and compared with the results from FY15, FY16, FY17 and FY18 in Figure 4-14. The set of particle penetration measurements obtained in FY15 through FY19 is narrowly distributed and is at least a factor of 2 lower than the requirement. No filters have failed the particle penetration test.

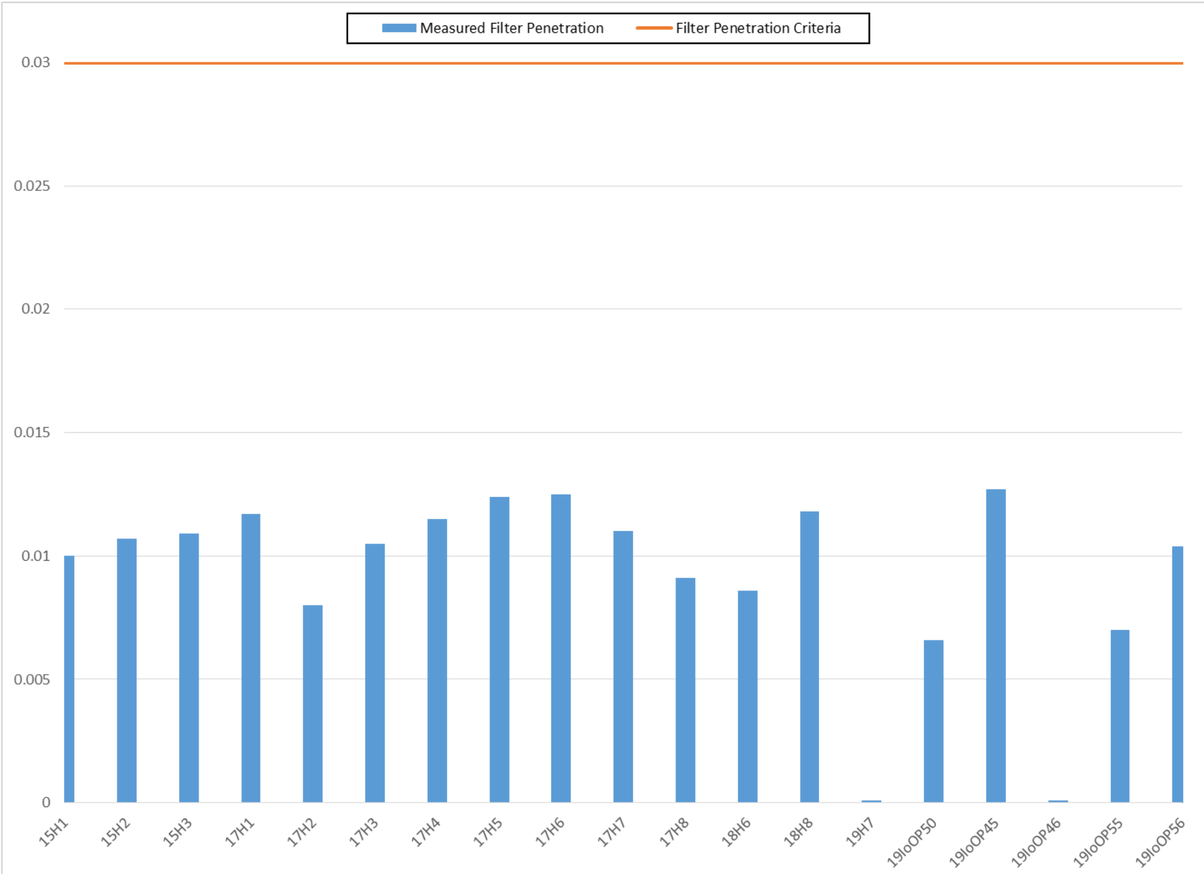



**Figure 4-14. Filter particle penetration measurements for each Hagan container measured from FY15 to FY19. The red line represents the upper bound for filter penetration. Values on y-axis are the filter efficiency.**

#### 4.1.3.2 Pressure Drop

Six Hagan containers were pressure drop tested in FY19 and compared with the results from FY15, FY16, FY17 and FY18 in Figure 4-15. The average for FY15 through FY19 is 0.635 in. W.C.

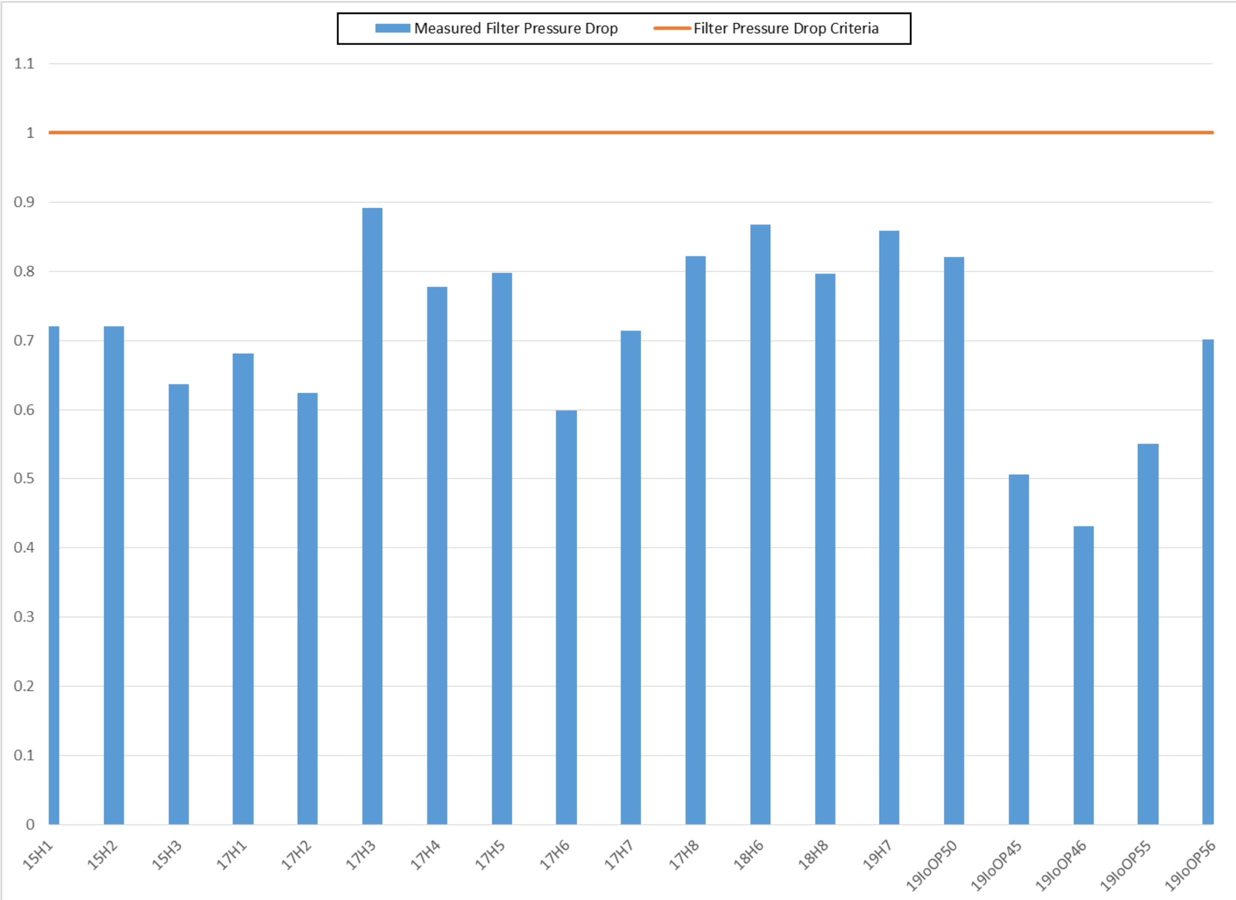



**Figure 4-15. Filter pressure drop measurements for each Hagan container measured from FY15 to FY19. The red line represents the upper bound for filter penetration. Values on y-axis are pressure drop in units of inches W.C.**

### *4.1.4 Corrosion*

Corrosion has been found on 8 of 9 Hagan containers targeted for surveillance this year. The amount of the corrosion in 2 of the Hagan containers was minor in appearance and seemed to be in close proximity to the PVC bag or tape. The corrosion on Hagan container 19H5 was the worst observed in any container in FY19 and was comparable to the corrosion seen in 18H7, which had large, agglomerated corrosion pits that are hundreds of microns in diameter and up to 40 microns deep [5]. The corrosion in this container was observed beyond the O-ring seal resulting in the lid being stuck in place on the container. This 1-quart container was packaged with an MSE salt (R83). The major factor resulting in the extensive corrosion was the 5.7 W irradiating a PVC bag-out bag in a small volume for 12.4 years. A more comprehensive analysis of the corrosion observed in FY19 can be found in the FY19 corrosion report [8].

The container management team formed a corrosion working group, bringing together people from the 3013 studies and SAVY 4000/Hagan surveillance team members to further investigate the corrosion effects and guide the container surveillance. Surveillance in FY20 will continue to target containers with a high likelihood for corrosion. These containers include other containers with MSE salts with a high wattage to volume ratio or bag degradation factor [9]. Additionally, the future surveillance will target other material forms and material types not yet included in the surveillance program to investigate corrosion in these containers.

## 4.2 SAVY 4000

The results for the SAVY 4000 storage containers are summarized in Table 14 Surveillance test results for SAVY 4000 storage containers. Table 14 Surveillance test results for SAVY 4000 storage containers. All O-rings passed a helium leakage test and durometer measurements. All filters passed the criteria for efficiency and pressure drop that were tested. Not all SAVY 4000 storage containers were returned to service in FY19 due to time constraints with the nuclear material handlers and the time it takes to complete the suite of container surveillance activities.

**Table 14 Surveillance test results for SAVY 4000 storage containers.**

| ID | Container Serial No. and Size | Container Visual Inspection | Corrosion Ranking | O-Ring Visual Inspection | Material Name and IDC | Sample Power (W) | Package Age (y) | Filter Particle Penetration (%) ± 0.0002 | Filter Pressure Drop (in W.C) ± 0.02 | Helium Leakage Rate $(\frac{atm-cc}{s})$ | O-ring Durometer (Shore M) ± 2.15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19S1 | 111308080<br>8 Quart | There is evidence of corrosion on the inner surfaces of the container. SME approves for use. Thumb latch is slightly stiff when used. | 2 | Nothing of note | BLO-39-11-16<br>C21 | 5 | 3.7 | 0.0001 | 0.594 | 6.30E-08 | 56.5 |
| 19S2 | 031105052<br>5 Quart | Nothing of note. | 0 | Nothing of note | CXLOX082911<br>C21 | 2.1 | 7.4 | 0.0001 | 0.47 | 1.5E-08 | 56.1 |

| ID | Container Serial No. and Size | Container Visual Inspection | Corrosion Ranking | O-Ring Visual Inspection | Material Name and IDC | Sample Power (W) | Package Age (y) | Filter Particle Penetration (%) ± 0.0002 | Filter Pressure Drop (in W.C) ± 0.02 | Helium Leakage Rate $(\frac{atm-cc}{s})$ | O-ring Durometer (Shore M) ± 2.15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19S3 | 121103083<br>3 Quart | This container was showing early signs of general corrosion but was wiped off for decon. so we can test it. The container looks clean after wiping and there is white fixed powder outside the filter and it wiped clean | 1 | Nothing of note | XBLSCL1217<br>R83 | 2.9 | 6.4 | NM | NM | 4.90E-07 | 56.2 |
| 19S4 | 031105051<br>5 Quart | Nothing of note. | 1 | Nothing of note | ROTRBJ-1C1<br>R26 | 1.2 | 7.9 | 0.0001 | 0.519 | 2.30E-08 | 56.2 |
| 19S5 | 111308059<br>8 Quart | Nothing of note. | 0 | Small inclusion from manufacturing O-ring is still good. | XAP6 (Outer)<br>M44 | 0.2 | 3.5 | NM | NM | 5.00E-07 | 56.6 |

| ID | Container Serial No. and Size | Container Visual Inspection | Corrosion Ranking | O-Ring Visual Inspection | Material Name and IDC | Sample Power (W) | Package Age (y) | Filter Particle Penetration (%) ± 0.0002 | Filter Pressure Drop (in W.C) ± 0.02 | Helium Leakage Rate $(\frac{atm-cc}{s})$ | O-ring Durometer (Shore M) ± 2.15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19S6 | 031105002<br>5 Quart | This is a capped SAVY that is in 111308059. There is a small crease on bottom radius | 0 | Nothing of note | XAP6 (Inner)<br>M44 | 0.2 | 7.6 | NM | NM | 5.70E-08 | 54.7 |
| 19S9 | 091205182<br>5 Quart | Small traces of plastic residue at the bottom of the container, container still passes | 0 | Small black inclusions from manufacturing still good. | POX4275C1<br>R78 | 2.7 | 6.4 | 0.0002 | 0.632 | 3.10E-08 | 56.7 |
| 19S10 | 111103001<br>3 Quart | Container looks great | 0 | Nothing of note. | SWPVTB15<br>R71 | 1.8 | 6.5 | 0 | 0.525 | 2.30E-08 | 55.8 |

| ID | Container Serial No. and Size | Container Visual Inspection | Corrosion Ranking | O-Ring Visual Inspection | Material Name and IDC | Sample Power (W) | Package Age (y) | Filter Particle Penetration (%) ± 0.0002 | Filter Pressure Drop (in W.C) ± 0.02 | Helium Leakage Rate $(\frac{atm-cc}{s})$ | O-ring Durometer (Shore M) ± 2.15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19S11 | 091205175<br>5 Quart | Small Crease on the bottom of the body, NOTE RCT dropped lid during unpacking no damage to lid. There is corrosion present throughout the inside of the container extending to the o-ring groove but not passed it. Decided to put this back in service to monitor as a part of our surveillance. | 1 | Small back spot inclusion from manufacturing still good | XBSOX153<br>R42 | 2.8 | 6.4 | 0 | 0.68 | 2.60E-08 | 55.7 |

| ID | Container Serial No. and Size | Container Visual Inspection | Corrosion Ranking | O-Ring Visual Inspection | Material Name and IDC | Sample Power (W) | Package Age (y) | Filter Particle Penetration (%) ± 0.0002 | Filter Pressure Drop (in W.C) ± 0.02 | Helium Leakage Rate ($\frac{atm-cc}{s}$) | O-ring Durometer (Shore M) ± 2.15 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 19S13 | 081305008<br>5Quart | There is corrosion and pitting throughout the container. | 2 | Some discoloration from manufacturing | RBXS5657-2A<br>C21 | 10.5 | 3.8 | 0.0005 | 0.551 | 5.50E-08 | 56.9 |

#### 4.2.1 Visual Inspections

Visual inspections of each container revealed SAVY 4000 containers with corrosion issues. Photographs of these containers were taken and the containers are held if further analysis is determined to be necessary.

##### 4.2.1.1 SAVY 4000 Container, Surveillance, Sample 19S1, SN 111308080, BLO-39-11-16, MT57, 544g, C21, Compound; Dioxide, 5 W, 3.7 years

Container 19S1 was packed with MT57 dioxide. This container has been surveilled 3 years now. The item is in a metal slip lid container with a PVC bag around it. Samples of a possible alternate bag-out bag material were placed into 111308080 in FY17 and during this year's surveillance, 1 of the samples was removed so that the condition of the alternative material could be evaluated. The results of the alternative bag-out bag evaluation will be reported in a future bag-out bag report.

**Table 15. Unpacking Data for Sample 19S1**

| Surveillance sample number | 19S1 |
|---|---|
| Person performing the repack | Mike Ramos |
| Date of Unloading | 6/20/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 111308080<br>Lid: 111308080 |
| Overall Package Weight Before Unloading: | 11117.1 g |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | No |
| Condition? | Like new bag |
| Any liquid observed inside/outside the bag-out-bag? | No, but residue on inside |
| Type of inner container: | Hagan |
| Item content verification: | BLO-39-11-16 |
| Condition of inner container? | Corroded, heavy corrosion on Hagan inside of bag |
| Will bag-out bag be replaced before re-pack? | No |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not measured |
| Comments: | N/A |

There is residue around the inside wall of the container (Figure 4-16) and corrosion around the weld inside the container (Figure 4-17). The O-ring passed the visual inspection, but did have small inclusions but not enough to comprise the seal. The bag-out bag was reported in good condition.

**Figure 4-16. Alternate bag-out bag sample in 19S1.**

**Figure 4-17. Corrosion around weld in 19S1.**

#### 4.2.1.2 SAVY 4000 Container, Surveillance, Sample 19S2, SN 031105052, CXLOX082911, MT52, 786.9g, C21, Dioxide, 2.1 W, 7.4 years

Container 19S2 was packed with MT52 dioxide. This container has been surveilled 5 years now. The item is in a metal slip lid container with a PVC bag around it. Light residue was seen on the inside of 19S2. The bag appears to be in good condition and was reported to be in "like new" condition. This container will likely be re-surveilled in future years.

**Table 16. Unpacking Data for Sample 19S2**

| Surveillance sample number | 19S2 |
|---|---|
| Person performing the repack | Mike Ramos |
| Date of Unloading | 6/20/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 031105052 |
| | Lid: 031105052 |
| Overall Package Weight Before Unloading: | Not measured |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | No |
| Condition? | Like new |
| Any liquid observed inside/outside the bag-out-bag? | No |
| Type of inner container: | Taped slip lid |
| Item content verification: | CXLOX082911 |
| Condition of inner container? | Slight corrosion on surfaces |
| Will bag-out bag be replaced before re-pack? | No |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not measured |
| Comments: | N/A |


**Figure 4-18 Visual inspection results of 19S2 during unpacking. (A) Inside surfaces of 19S2 that is showing no signs of corrosion. (B) Bag-out bag around item in 19S2 showing minor signs of degradation.**

#### 4.2.1.3 SAVY 4000 Container, Surveillance, Sample 19S3, SN 121103083, XBLSCL1217, MT52+44, 178.5g+10.6g, R83, MSE Salt, 2.9 W, 6.4 years

Container 19S3 was packed with MT52 and MT44 MSE Salt. This container has been surveilled 5 years now. The item is in a metal slip lid container with a PVC bag around it. Lite residue and corrosion were seen on the inside of 19S3. The bag appears to be in good condition and was reported to be in "good" condition. According to the unpack form the bag had failed and the contamination was measured at 1000 dpm.

**Table 17. Unpacking Data for Sample 19S3**

| Surveillance sample number | 19S3 |
|---|---|
| Person performing the repack | Mike Ramos |
| Date of Unloading | 8/22/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 121103083 |
| | Lid: 121103083 |
| Overall Package Weight Before Unloading: | Not measured |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | No |
| Condition? | Bag-out bag failed (1000 dpm) |
| Any liquid observed inside/outside the bag-out-bag? | Unknown |
| Type of inner container: | Taped slip lid |
| Item content verification: | XBLSCL1217 |
| Condition of inner container? | Good, 3 Qt inner 121103083 |
| Will bag-out bag be replaced before re-pack? | Unknown |
| Will inner container be replaced before re-pack? | Unknown |
| Overall package weight after repack: | Not measured |
| Comments: | N/A |

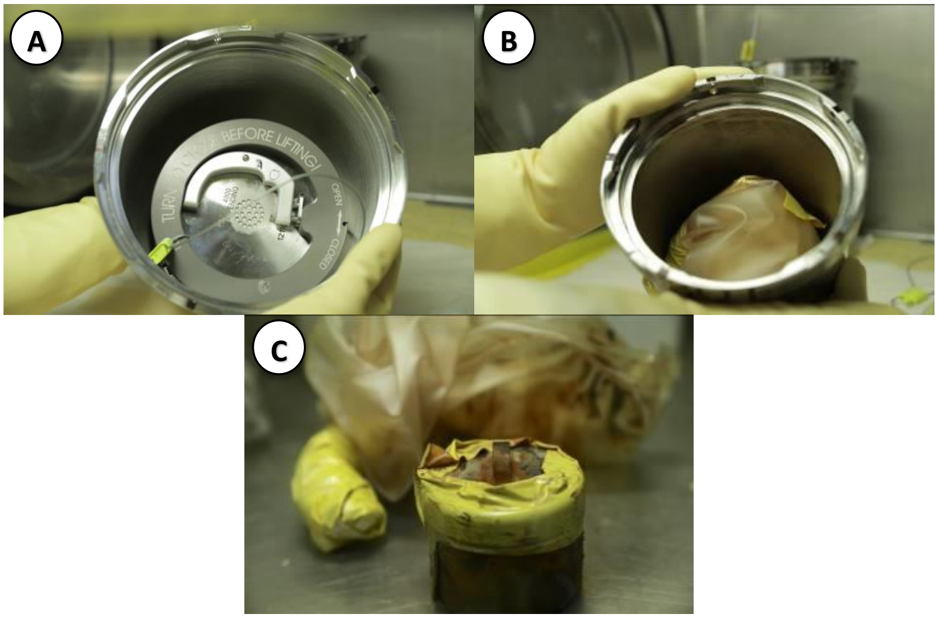


**Figure 4-19 Visual inspection results of 19S3 during unpacking. (A) Evidence of white residue near the filter of 19S3. (B) There is some corrosion found on the inner surfaces of 19S3 and a bag that "appears" to be in good shape. (C) Corrosion can be found on the inner container.**

In the visual inspection it was noted that the container is experiencing early signs of general corrosion but was wiped off during the decontamination that resulted from the failed bag-out bag. White residue was observed near the filter but was wipe able and was cleaned off during the surveillance activities.

#### *4.2.1.4 SAVY 4000 Container, Surveillance, Sample 19S4, SN 031105051, ROTRBJ-1C1, MT52, 452g, R26, Filter Residue, 1.2 W, 7.9 years*

Container 19S4 was packed with MT52 filter residue. This container has been surveilled 5 years now. The item is in a metal slip lid container with a PVC bag around it. Light residue was seen on the inside of 19S4. The bag appears to be in good condition and was reported to be in "like new" condition.

**Table 18. Unpacking Data for Sample 19S4**

| Surveillance sample number | 19S4 |
|---|---|
| Person performing the repack | Mike Ramos |
| Date of Unloading | 6/20/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 031105051 |
| | Lid: 031105051 |
| Overall Package Weight Before Unloading: | Not measured |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | No |
| Condition? | Like new bag |
| Any liquid observed inside/outside the bag-out-bag? | No |
| Type of inner container: | Taped slip lid |
| Item content verification: | ROTRBJ-1C1 |
| Condition of inner container? | Corroded, slight corrosion on surfaces |
| Will bag-out bag be replaced before re-pack? | No |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not measured |
| Comments: | N/A |


**Figure 4-20 Visual inspection results of 19S4 during unpacking. (A) Some bag residue was found on the inner surfaces of 19S4 with no evidence of corrosion. (B) Two or more bags have been used as contamination control around the inner container.**

The visual inspection turned up nothing of note.

##### 4.2.1.5 SAVY 4000 Container, Surveillance, Sample 19S5, SN 111308059, XAP6 (Outer), MT53, 69.5g, M44, Unalloyed Metal, 0.2 W, 3.5 years

Container 19S5 was packaged with MT53 unalloyed metal. This container has been surveilled twice before this years surveillance. Packaged inside of 19S5 was a hermetic capped SAVY, 19S6. The inside of 19S5 was clean as expected and did not show any signs of degradation.

**Table 19. Unpacking Data for Sample 19S5**

| Surveillance sample number | 19S5 |
|---|---|
| Person performing the repack | Mike Ramos |
| Date of Unloading | 8/22/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 111308059 |
| | Lid: 111308059 |
| Overall Package Weight Before Unloading: | Not measured |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | Yes |
| Condition? | No bag on inner |
| Any liquid observed inside/outside the bag-out-bag? | No |
| Type of inner container: | Capped 5 qt SAVY (photo) |
| Item content verification: | XAP6 |
| Condition of inner container? | Good, like new |
| Will bag-out bag be replaced before re-pack? | N/A |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not measured |
| Comments: | N/A |

#### *4.2.1.6 SAVY 4000 Container, Surveillance, Sample 19S6, SN 031105002, XAP6 (Inner), MT53, 69.5g, M44, Unalloyed Metal, 2.9 W, 4.9 years*

Container 19S6 was packed with MT53 and unalloyed metal. This container has only been surveilled this one time. There is a PVC bag around the unknown inner container it. A small amount of residue was on the inner surface of 19S6. A small dent was noted in the visual inspection near the bottom radius.

**Table 20. Unpacking Data for Sample 19S6**

| Surveillance sample number | 19S6 |
|---|---|
| Person performing the repack | Mike Ramos |
| Date of Unloading | 8/22/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 031105002 |
| | Lid: 031105002 |
| Overall Package Weight Before Unloading: | Not measured |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | Yes |
| Condition? | Bag stuck to inner surfaces. Hermetic cap in good condition |
| Any liquid observed inside/outside the bag-out-bag? | No |
| Type of inner container: | Unknown |
| Item content verification: | XAP6 |
| Condition of inner container? | Unknown |
| Will bag-out bag be replaced before re-pack? | No |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not measured |
| Comments: | N/A |


**Figure 4-21 Visual inspection results of 19S6 during unpacking. (A) The hermetic cap on 19S6 appears to be in good condition. (B) The bag inside of 19S6 is starting to discolor slightly. (C) Some bag residue was found on the inner surfaces of container 19S6.**

### 4.2.1.7 SAVY 4000 Container, Surveillance, Sample 19S9, SN 091205182, POX4275C1, MT52, 1037.4g, R78, Sweepings, 2.7 W, 6.4 years

Container 19S9 was packed with MT52 sweepings. This was the first time 091205182 has been surveilled. Although the bag-out bag inside of this container was heavily discolored the containers inner surfaces had a very small amount of residue and not corrosion. There were no other observations made in the visual inspection.

**Table 21. Unpacking Data for Sample 19S9**

| Surveillance sample number | 19S9 |
|---|---|
| Person performing the repack | Kennard Wilson |
| Date of Unloading | 7/30/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 091205182 |
| | Lid: 091205182 |
| Overall Package Weight Before Unloading: | 6948.1g |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | Unknown |
| Condition? | Brown, but pliable |
| Any liquid observed inside/outside the bag-out-bag? | Small amounts of liquid residue on bottom of SAVY (photo |
| Type of inner container: | Unknown |
| Item content verification: | POX4275C1 |
| Condition of inner container? | Unknown |
| Will bag-out bag be replaced before re-pack? | No |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not measured |
| Comments: | N/A |

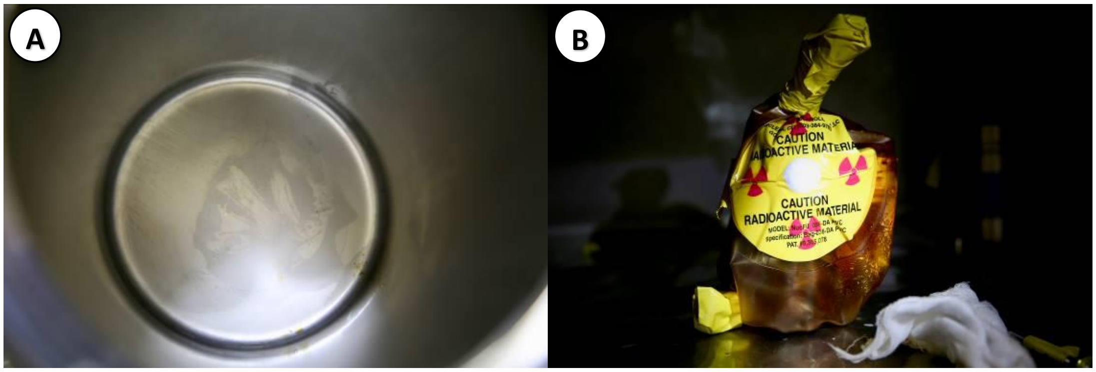



**Figure 4-22 Visual inspection results of 19S9 during unpacking. (A) Liquid bag residue is seen in the bottom of 19S9. (B) Bag-out bag is heavily discolored.**

#### *4.2.1.8 SAVY 4000 Container, Surveillance, Sample 19S10, SN 111103001, SWPVTB15, MT52, 678g, R71, Salt, 1.8 W, 6.5 years*

Container 19S10 was packaged with MT52 salt. FY19 was the first year SAVY 111103001 has been surveilled. A small amount of residue was inside of the container. The visual inspection form indicated that the container was in “great condition”.

**Table 22. Unpacking Data for Sample 19S10**

| Surveillance sample number | 19S10 |
|---|---|
| Person performing the repack | Kennard Wilson |
| Date of Unloading | 7/31/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 111103001 |
| | Lid: 111103001 |
| Overall Package Weight Before Unloading: | 5024.1g |
| Outer Container Condition: | Good |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | No |
| Condition? | Clear |
| Any liquid observed inside/outside the bag-out-bag? | No |
| Type of inner container: | Taped slip-lid |
| Item content verification: | SWPVTB15 |
| Condition of inner container? | Small amounts of corrosion |
| Will bag-out bag be replaced before re-pack? | No |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not measured |
| Comments: | N/A |

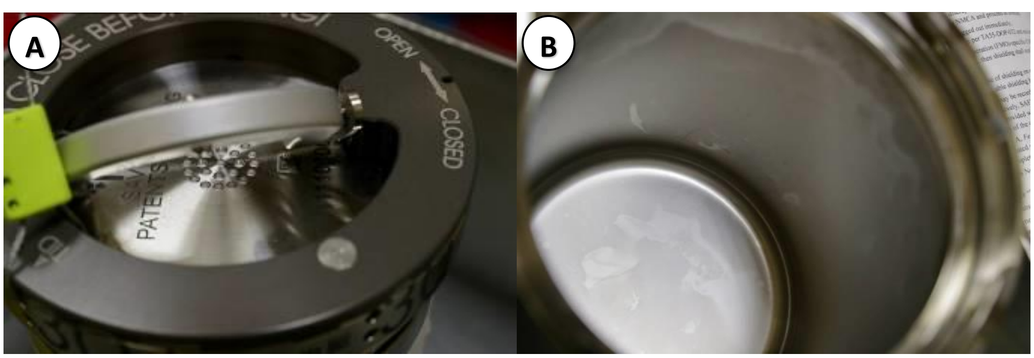



**Figure 4-23 Visual inspection results of 19S10 during unpacking. (A) No evidence of white residue on the outside of the filter. (B) Some bag residue can be seen on the inside surfaces of 19S10.**

#### 4.2.1.9 SAVY 4000 Container, Surveillance, Sample 19S11, SN 091205175, XBSOX153, MT52, 1079g, R42, DOR Salt, 2.8 W, 6.4 years

Container 19S11 was packaged with MT52 DOR salt. FY19 was the first year SAVY 091205175 has been surveilled. Both residue and corrosion was found inside of the container 19S11. The corrosion on the inner surfaces was lite. A small dent was noted on the container body in the visual inspection. It is also noted that the lid was dropped while it was being RCT released. The corrosion that was present extended up to the o-ring but did not go past the o-ring.

**Table 23 Unpacking Data for Sample 19S11**

| Surveillance sample number | 19S11 |
|---|---|
| Person performing the repack | Kennard Wilson |
| Date of Unloading | 7/30/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 091205175 |
| | Lid: 091205175 |
| Overall Package Weight Before Unloading: | 8553.6g |
| Outer Container Condition: | Corrosion found on inside surfaces (photo) |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | No |
| Condition? | Clear |
| Any liquid observed inside/outside the bag-out-bag? | Pliable yellow/brown bag |
| Type of inner container: | Taped slip-lid |
| Item content verification: | XBSOX153 |
| Condition of inner container? | Unknown |
| Will bag-out bag be replaced before re-pack? | No |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not measured |
| Comments: | N/A |

**Figure 4-24 Visual inspection results of 19S11 during unpacking. Areas of corrosion on inner surfaces of 19S11**

**Figure 4-25 Visual inspection results of 19S11 during unpacking. Corrosion on inner surfaces of 19S11.**

**Figure 4-26 Visual inspection results of 19S11 during unpacking. Corrosion on underside of lid of 19S11.**

#### *4.2.1.10 SAVY 4000 Container, Surveillance, Sample 19S13, SN 081305008, RBXS5657-2A, MT56, 2059g, C21, Dioxide, 10.5 W, 3.8 years*

Container 19S13 was packaged with MT56 dioxide. FY19 was the first year SAVY 081305008 has been surveilled. 19S13 had the most significant amount of corrosion in a SAVY in an FY19 container had. The corrosion covered a large portion of the inner surfaces. Container 19S13 was not put back into service due to the extent of corrosion.

**Table 24 Unpacking Data for Sample 19S13**

| Surveillance sample number | 19S13 |
|---|---|
| Person performing the repack | Kennard Wilson |
| Date of Unloading | 8/7/2019 |
| SAVY 4000 or Hagan Serial #'s: | Body: 081305008 |
| | Lid: 081305008 |
| Overall Package Weight Before Unloading: | 8506.7g w/ shielding |
| Outer Container Condition: | good |
| Pewter Outer Shielding present? | Yes |
| Contamination found outside SAVY? | No |
| Contamination found inside surfaces SAVY? | No |
| O-ring installed? | Yes |
| Pewter Internal shielding present? | No |
| Condition? | Black bag |
| Any liquid observed inside/outside the bag-out-bag? | Plasticizer present. Bag is black/flexible |
| Type of inner container: | Unknown |
| Item content verification: | RBXS5657-2A |
| Condition of inner container? | Unknown |
| Will bag-out bag be replaced before re-pack? | No |
| Will inner container be replaced before re-pack? | No |
| Overall package weight after repack: | Not measured |
| Comments: | N/A |

**Figure 4-27 Visual inspection results of 19S13 during unpacking. Corrosion can is seen covering a large portion of the inner surfaces of 19S13 with areas of native metal surrounding them.**

**Figure 4-28 Visual inspection results of 19S13 during unpacking. The underside of the lid was found to have a considerable amount of corrosion.**

### 4.2.2 O-ring Tests

#### 4.2.2.1 Visual Inspection of the O-rings

Inspections revealed small amounts of dust and debris on a majority of the O-rings. It is unclear whether this dirt was introduced during the use of the container or during manipulations involved in surveillance. In either case, the dirt was easily removed with an alcohol wipe. Four of the SAVY 4000 o-rings inspected in FY19 had dark inclusions that were thought to have come from the manufacturer. No other flaws were found either the surveillance containers or the transfer containers.

#### 4.2.2.2 Container Leakage Rate Tests

The leakage rate results for storage containers with O-rings installed are shown in Figure 4-29. For storage containers in fy19, the measured leakage rate ranged between $1.5 \times 10^{-8}$ and $5.0 \times 10^{-9}$ atm cc/s of helium at 75 Torr into vacuum. Every SAVY 4000 in FY19 passed the leakage test, with all measurements being below the failure criterion of $1 \times 10^{-5}$ atm cc/s.

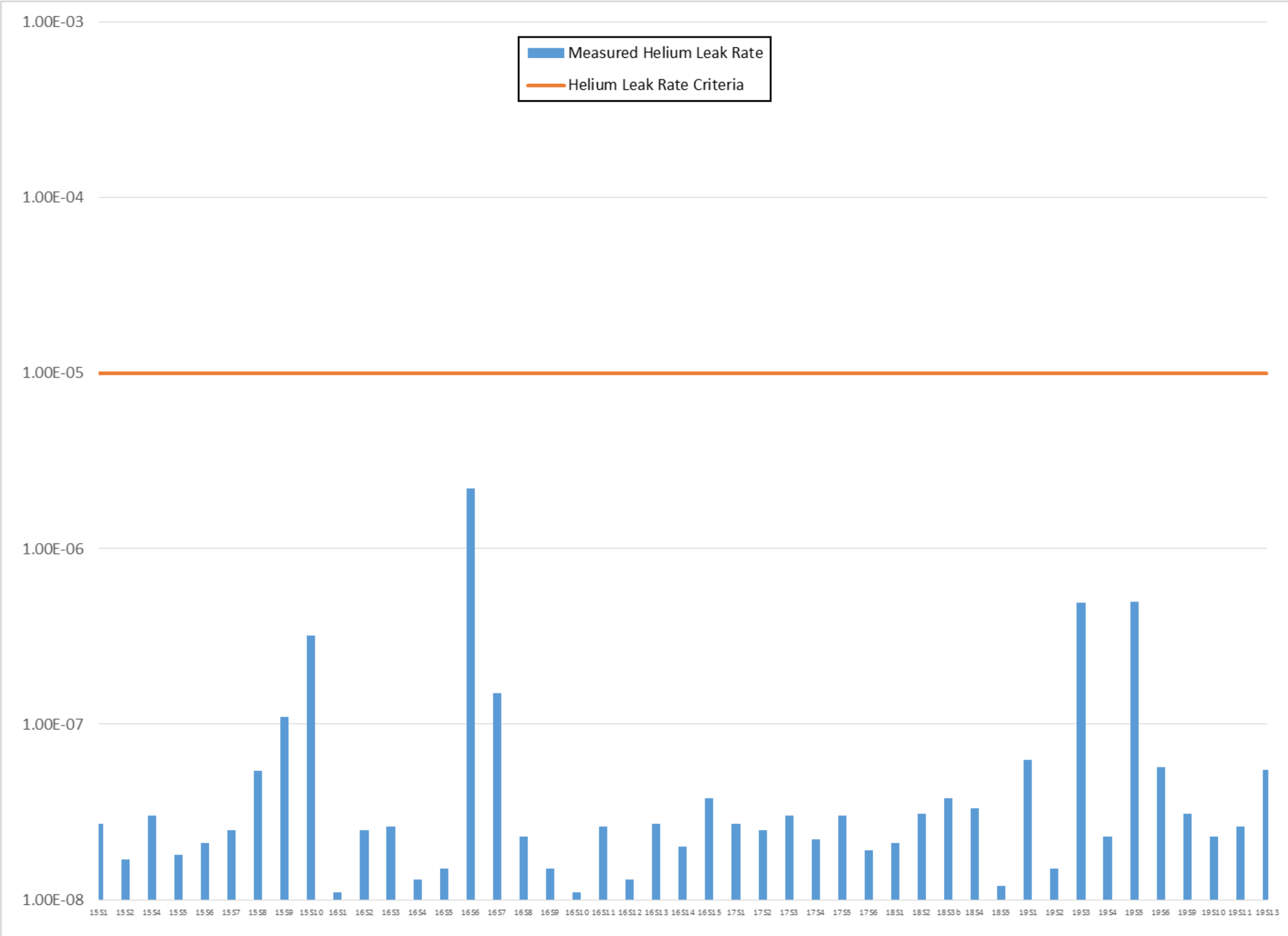



**Figure 4-29. Leakage rates for surveillance containers, measured for each container are shown as blue bars with the failure criteria shown with the orange line.**

Leakage testing is done as a threshold measurement on a logarithmic scale. Only a single point calibration is done to prepare the instrument for use, though it is checked against another, known leakage standard. The calibration value is chosen that is low enough to ensure that the threshold leak—the leakage at which failure of a part is determined—is certain to register on the leakage detector but high enough to be distinguishable from background. The value of the apparent background leakage rate will always decrease during a leakage test, as gas is continuously evacuated from the bell jar, so it is not unusual to see leakage test measurements lower than the background. This means that the leakage test measurement is indistinguishable from the background. These values show measured leakage rates that are indistinguishable from the apparent background, and therefore we have confidence containment has been maintained well below the design release rate. The leakage test measurement does not have a significant correlation with age, estimated dose, or item thermal power.

#### 4.2.2.3 O-ring Hardness Tests

The 10 surveillance O-rings from FY19 were found to have hardness of between 54.7 and 56.9, with an average of 57.5 durometer units. The 21 transfer container O-rings had a hardness between 56.2 and 58.6, with an average of 56.1 durometer units. The 28 O-rings used as a baseline in the lifetime extension studies have a hardness of 57.5 ±2.62 durometer units, so the storage O-rings are similar in hardness to unused O-rings. The 2.62 unit error is the reproducibility standard deviation as given in ASTM D2240. The measurements are graphed in Figure 4-30**.** None of the O-rings are especially hard or soft compared with the baseline, and the measurement do not have a significant correlation with age, estimated dose, or item thermal power.

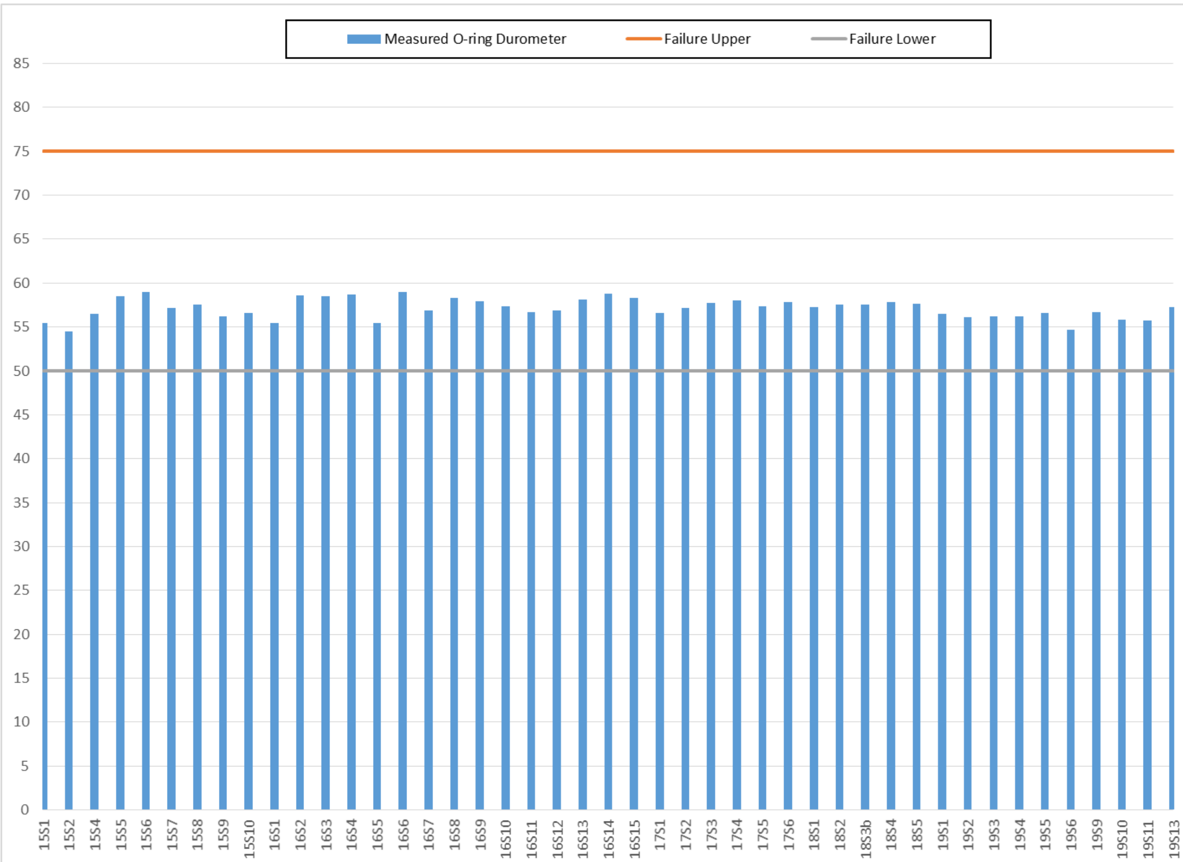



**Figure 4-30. Durometer measurements of the surveillance SAVY 4000 O-ring with the red and green and red bands showing the upper and lower failure limits.**

### 4.2.3 Filter Tests

#### 4.2.3.1 Particle Penetration

The aerosol data are reported as a percent penetration, also known as the percent leakage. The set of particle penetration measurements is narrowly distributed and very far from the failure criterion as graphed in Figure 4-31 for storage containers and Figure 4-32 for transfer containers. A set of baseline particle penetration measurements does exist, but it is not clear how those measurements, taken on a different type of instrument with a different configuration, relate to the measurements taken in PF-4 with our instrument. Although we may not be able to tell how the particle penetration is changing from baseline, we will be able to track how the particle penetration changes relative to containers' peers in the sample population.

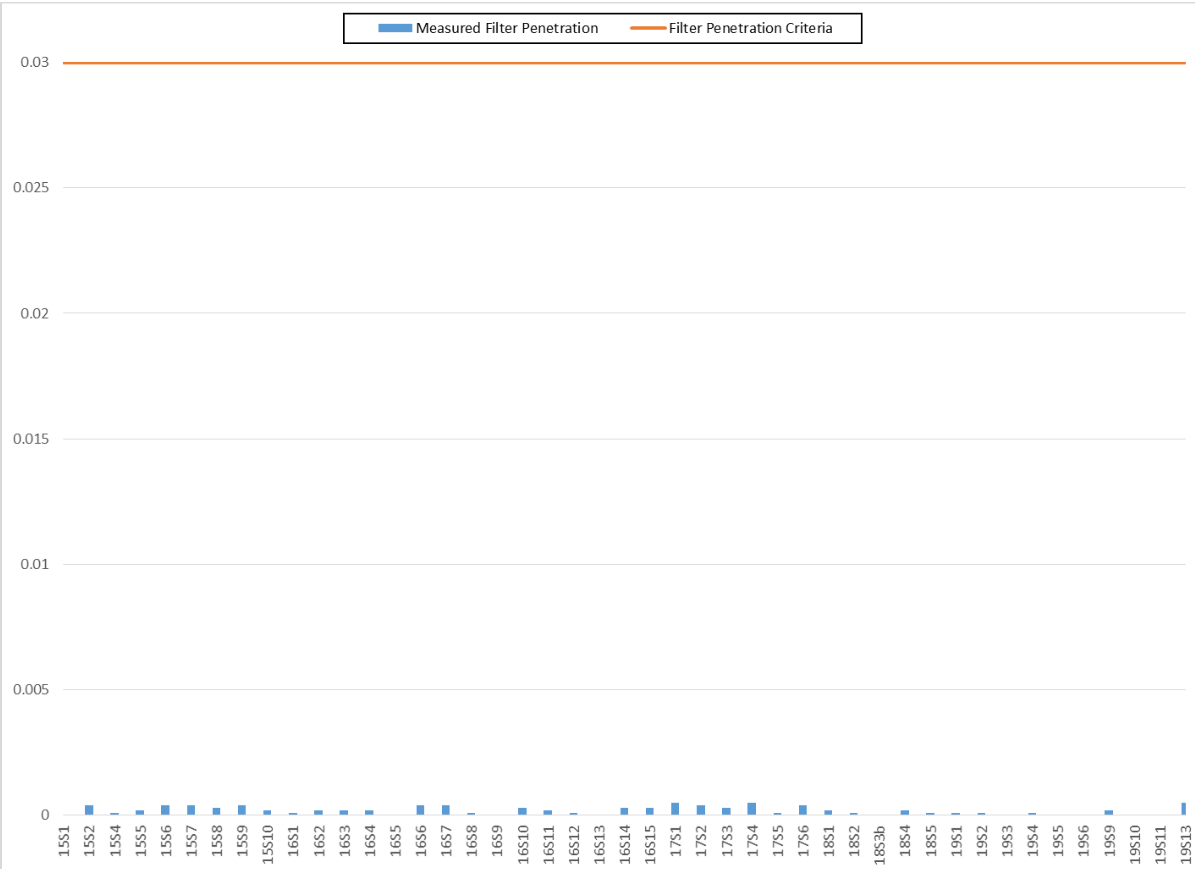



**Figure 4-31. Filter particle penetration measurements for storage containers.**

### 4.2.3.2 Pressure Drop

The pressure drop measurements have an average of 0.58 in. W.C. ±0.07 for FY19 storage. The results are graphed below in Figure 4-32.

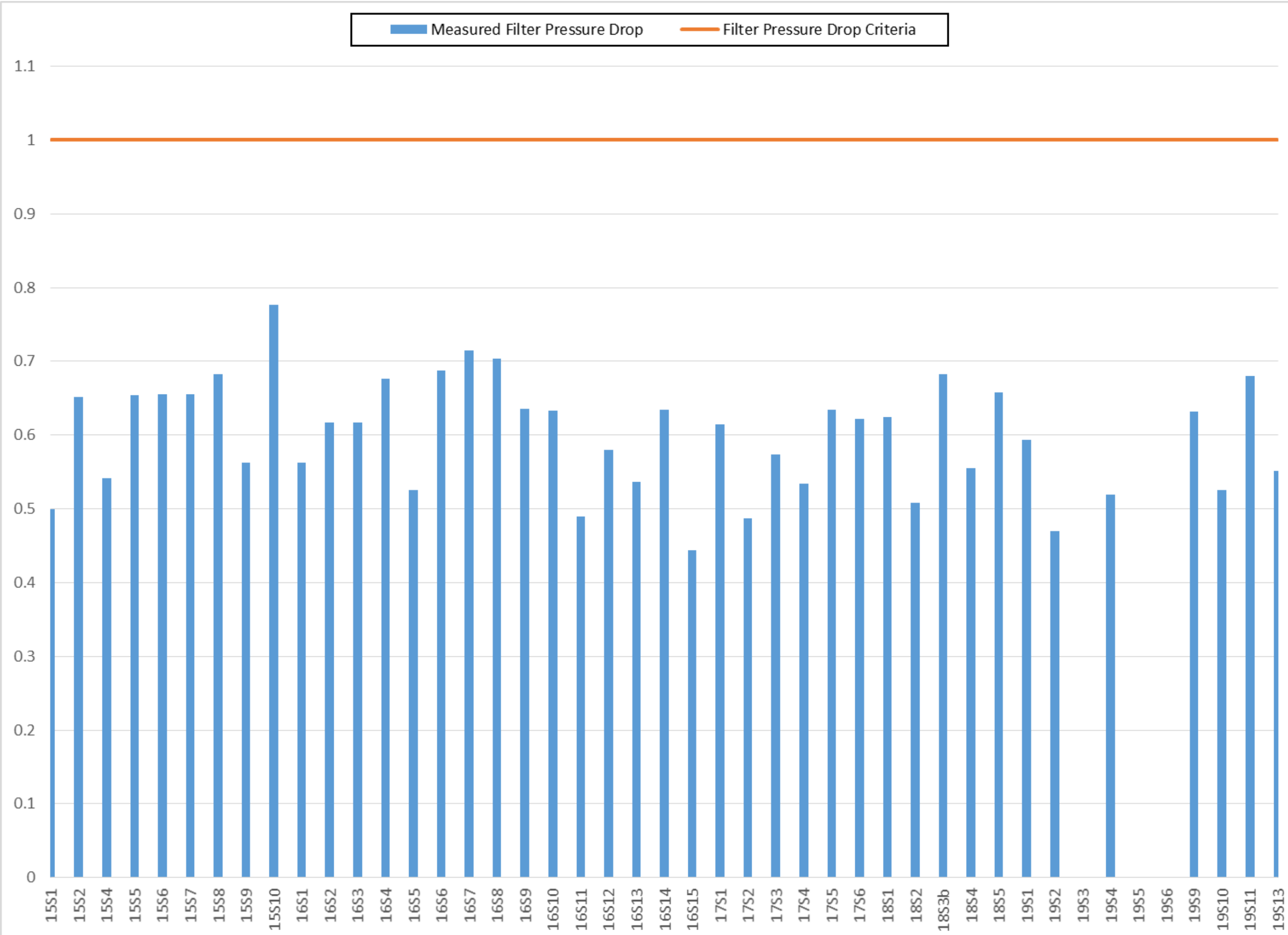



**Figure 4-32. Filter pressure drop measurements for storage containers. Where**

### *4.2.4 Annual Surveillance*

Five of the containers have been designated for annual surveillance in the Surveillance Plan[1]. The relevant data for annual measurements on the five nondestructive evaluation (NDE)–only containers are reproduced in Table 25 thru Table 29.

**Table 25. Relevant data for annual measurements on the five annual surveillance containers.**

| **SAVY 4000 Serial Number**<br>**LANMAS ID** | **031105052(L/B)**<br>CXLOX082911 |
|---|---|
| Material Type | 52 |
| IDC | C217 |
| Chemical Form | Compound Dioxide |
| Material Creation Date | 2011-09-19 |
| Material Mass (g) | 786.9 |
| Material Wattage (W) | 2.07 |
| Initial Packaging Date | 2012-01-18 |

**Surveillance Data**

| Surv FY | Surv. Date | SAVY 4000 Age (y) | Leakage Rate (atm-cc/s) | O-ring Durometer (Shore M) | Filter Pressure Drop (in. W.C.) | Particle Penetration (%) | Initial Package Mass (g) | Repackaged. Mass (g) |
|---|---|---|---|---|---|---|---|---|
| FY15 | 2015-08-26 | 3.03 | $2.5\times10^{-8}$ | 57.2 | 0.563 | 0.0004 | 3136.2 | 6755.5 |
| FY16 | 2016-03-07 | 4.13 | $2.6\times10^{-8}$ | 56.7 | 0.49 | 0.0002 | 6758.5 | 6752.3 |
| FY17 | 2017-03-14 | 5.16 | $1.3\times10^{-8}$ | 57.2 | 0.49 | 0.0004 | 5199.3 | N/A |
| FY18 | 2018-3-01 | 6.1 | $3.1x10^{-8}$ | 57.5 | 0.51 | 0.0001 | 6763.1 | N/A |
| FY19 | 2019-06-20 | 7.4 | $1.5x10^{-8}$ | 56.1 | 0.47 | 0.0001 | N/A | N/A |

**Surveillance Observations**

| Surv FY | Container Inspection | Corrosion Ranking | Bag Inspection |
|---|---|---|---|
| FY15 | No comments entered | 0 | Good |
| FY16 | Filter has no debris or discoloration | 0 | Good |
| FY17 | No comments entered | 0 | Good |
| FY18 | Thumb latch is a little sticky but still works | | Good |
| FY19 | No comment entered | 0 | Good |

**Table 26. Relevant data for annual measurements on the five annual surveillance containers.**

| **SAVY 4000 Serial Number**<br>**LANMAS ID** | **031105051(L/B)**<br>**ROTRBJ-1C1** |
|---|---|
| Material Type | 52 |
| IDC | R260 |
| Chemical Form | Process Residue, Filter Residue |
| Material Creation Date | 1992-11-03 |
| Material Mass (g) | 452 |
| Material Wattage (W) | 1.19 |
| Initial Packaging Date | 2011-08-16 |

**Surveillance Data**

| Surv FY | Surv. Date | SAVY 4000 Age (y) | Leakage Rate (atm-cc/s) | O-ring Durometer (Shore M) | Filter Pressure Drop (in. W.C.) | Particle Penetration (%) | Initial Package Mass (g) | Repackaged. Mass (g) |
|---|---|---|---|---|---|---|---|---|
| FY15 | 2015-01-29 | 3.01 | $3.0\times10^{-8}$ | 56.5 | 0.542 | 0.0001 | 8971.7 | 8992.8 |
| FY16 | 2016-03-07 | 4.11 | $2.7\times10^{-8}$ | 58.1 | 0.537 | 0.0000 | 8998.7 | 9193.9 |
| FY17 | 2017-03-14 | 5.58 | $2.2\times10^{-8}$ | 58.0 | 0.54 | 0.0005 | 7616. | N/A |
| FY18 | 2018-3-01 | 6.6 | $3.3x10^{-8}$ | 57.8 | 0.56 | 0.0002 | 9208.6 | N/A |
| FY19 | 2019-06-20 | 7.9 | $2.3x10^{-8}$ | 56.2 | .519 | 0.0001 | N/A | N/A |

**Surveillance Observations**

| Surv FY | Container Inspection | Corrosion Ranking | Bag Inspection |
|---|---|---|---|
| FY15 | No comments entered | 0 | Good, darkened |
| FY16 | Filter has no debris or discoloration | 0 | Brittle, not able to see inner container due to dark outer bag (added additional bag) |
| FY17 | Markings of bag-out bag on interior of container, possibly the beginning of corrosion. Container wiped with a slight removal of the suspected corrosion.<br>Photos taken both before and after wiping | 1 | Good (overbag) |
| FY18 | Sticky thumb latch and small amounts of residue throughout the inside of the container. Small dimple on bottom of the container. | | Good (overbag) |
| FY19 | No comment entered | 1 | Like new |

**Table 27. Relevant data for annual measurements on the five annual surveillance containers.**

| **SAVY 4000 Serial Number<br>LANMAS ID** | **121103083(L/B)<br>XBLSCL1217** |
|---|---|
| Material Type | 52+44 |
| IDC | R832 |
| Chemical Form | Process Residue, MSE Salt |
| Material Creation Date | 2012-10-07 |
| Material Mass (g) | Pu-178.5; Am-10.6 |
| Material Wattage (W) | 2.85 |
| Initial Packaging Date | 2013-03-21 |

**Surveillance Data**

| Surv FY | Surv. Date | SAVY 4000 Age (y) | Leakage Rate (atm-cc/s) | O-ring Durometer (Shore M) | Filter Pressure Drop (in. W.C.) | Particle Penetration (%) | Initial Package Mass (g) | Repackaged. Mass (g) |
|---|---|---|---|---|---|---|---|---|
| FY15 | 2015-01-29 | 1.86 | $1.7\times10^{-8}$ | 54.5 | 0.65 | 0.0004 | 4270.1 | 4268.5 |
| FY16 | 2016-03-07 | 2.96 | $2.0\times10^{-8}$ | 58.8 | 0.63 | 0.0003 | 4271.2 | 4266.7 |
| FY17 | 2017-03-14 | 3.98 | $1.0\times10^{-8}$ | 57.4 | 0.63 | 0.0001 | 3190.8 | N/A |
| FY18 | 2018-3-01 | 4.9 | $1.2\times10^{-8}$ | 57.6 | 0.66 | 0.0001 | 4275.4 | N/A |
| FY19 | 2019-08-22 | 6.4 | $4.9\text{x}10^{-7}$ | 56.2 | Not Measured | Not Measured | N/A | N/A |

**Surveillance Observations**

| Surv FY | Container Inspection | Corrosion Ranking | Bag Inspection |
|---|---|---|---|
| FY15 | No comments entered | 0 | Good |
| FY16 | No discoloration of the filter or any filter damage visually | 0 | Good |
| FY17 | Beginning signs of corrosion evident in the container, mainly on bottom and lower portion of container.<br>Container wiped with minimal change. Photos taking both before and after wiping | 1 | Good |
| FY18 | Early signs of corrosion throughout the inside of the container. Anodizing color on the locking ring has changed and is apparent by examining other areas of the locking ring. There is a sign/scratch on the locking ring of being dinged or hit against another object. | | Good |

| | | | |
|---|---|---|---|
| FY19 | This container was showing early signs of general corrosion but was wiped off for decon. so we can test it. The container looks clean after wiping and there is white fixed powder outside the filter and it wiped clean | 1 | Bag-out bag failed. |

**Table 28. Relevant data for annual measurements on the five annual surveillance containers.**

| **SAVY 4000 Serial Number<br>LANMAS ID** | **111308080(L/B)<br>BLO-39-11-16** |
|---|---|
| Material Type | **57** |
| IDC | C21 |
| Chemical Form | Dioxide |
| Material Creation Date | 2015-10-07 |
| Material Mass (g) | 544 |
| Material Wattage (W) | 5 |
| Initial Packaging Date | 2015-10-7 |

**Surveillance Data**

| Surv FY | Surv. Date | SAVY 4000 Age (y) | Leakage Rate (atm-cc/s) | O-ring Durometer (Shore M) | Filter Pressure Drop (in. W.C.) | Particle Penetration (%) | Initial Package Mass (g) | Repackaged. Mass (g) |
|---|---|---|---|---|---|---|---|---|
| FY17 | 2017-05-16 | 1.61 | $2.7\times10^{-8}$ | 56.6 | 0.62 | 0.0005 | 8620 | N/A |
| FY18 | 2018-3-01 | 2.4 | $2.1\times10^{-8}$ | 57.3 | 0.63 | 0.0002 | 11117.1 | N/A |
| FY19 | 2019-06-20 | 3.7 | $6.3\text{x}10^{-8}$ | 56.5 | 0.594 | 0.0001 | N/A | N/A |

**Surveillance Observations**

| Surv FY | Container Inspection | Corrosion Ranking | Bag Inspection |
|---|---|---|---|
| FY17 | Slight Corrosion on interior | 2 | Good, but new bag-out bag was placed around old bag. |
| FY18 | There is corrosion around the weld inside the container and residue around the inside the of the container | 2 | Good |
| FY19 | There is evidence of corrosion on the inner surfaces of the container. SME approves for use.<br>Thumb latch is slightly stiff when used. | 2 | Good |

**Table 29 Relevant data for annual measurements on the five annual surveillance containers.**

| **SAVY 4000 Serial Number<br>LANMAS ID** | **031105002 (L/B)<br>XAP6 (Inner)** |
|---|---|
| Material Type | 53 |
| IDC | M44 |
| Chemical Form | Unalloyed Metal |
| Material Creation Date | 2015-10-07 |
| Material Mass (g) | 69.5 |
| Material Wattage (W) | 0.2 |
| Initial Packaging Date | 2012-01-20 |

**Surveillance Data**

| Surv FY | Surv. Date | SAVY 4000 Age (y) | Leakage Rate (atm-cc/s) | O-ring Durometer (Shore M) | Filter Pressure Drop (in. W.C.) | Particle Penetration (%) | Initial Package Mass (g) | Repackaged. Mass (g) |
|---|---|---|---|---|---|---|---|---|
| FY16 | 2016-03-07 | 4.12 | $1.3\times10^{-8}$ | 56.9 | 0.58 | 0.0001 | 7431.7 | N/A |
| FY17 | 2017-03-14 | 5.15 | $3.0\times10^{-8}$ | 57.7 | 0.574 | 0.0003 | 5908.6 | N/A |
| FY19 | 2019-08-22 | 7.6 | $5.7\text{x}10^{-8}$ | 54.7 | Not Measured | Not Measured | N/A | N/A |

**Surveillance Observations**

| Surv FY | Container Inspection | Corrosion Ranking | Bag Inspection |
|---|---|---|---|
| FY16 | Filter looks good, no debris or discoloration. Latch and pin stuck when container was being closed. Rotating the handle back and forth allowed the pin to engage. Informed packing team of possible issue. | 0 | Good |
| FY17 | Markings of bag-out bag on interior of container. possibly the beginning of corrosion. Small dent of bottom radius. Thumb latch is sticky. Vacuum grease applied to latch and worked into mechanism which helped to loosen it up. Container wiped with minimal change. Photos taking both before and after wiping | 1 | Good |
| FY19 | This is a capped SAVY that is in 111308059. There is a small crease on bottom radius | 0 | Good |

## 4.3 Trending Analysis

One of the goals of surveillance is to evaluate trends over time for those measurements that have quantitative values, e.g., Helium (He) leakage rate, particle penetration, filter pressure drop, durometer (Shore M hardness) and compression set (CS). A trend analysis of these measurements can support O-ring lifetime extension assessments. In addition, a trend analysis can help identify containers whose measurements appear to be outliers when compared to those of the other containers. Outlier containers will be evaluated to determine if they should be re-examined in future surveillances.

### *4.3.1 Helium Leakage Rate*

Figure 4-33 shows He leakage rate versus age. The containers denoted with colored circles are the five containers that have been examined at least twice in 2015 through 2019. The black circles are the remainder of the SAVY surveillance containers (16 containers). The black horizontal line is the acceptance limit for He leakage rate. To date, there is no trend with time for leakage rate. This year there was a slight increase in the leakage rate for the XAP6 outer container (orange) and ROTRBJ-1C1 (green). There is one outlier, XBLSCL1213 (the highest black point) that was discovered in 2018. This container was corroded and it required cleaning to pass the leakage test. This container will be re-examined again in in a future surveillance. XAP6 outer container and ROTRBJ-1C1 will also be re-examined in future surveillances.

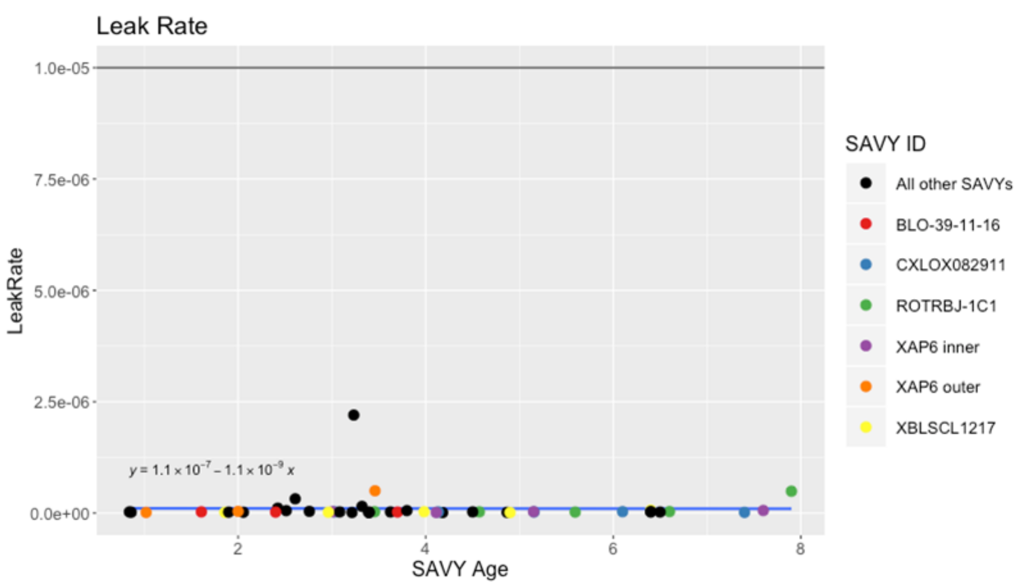



**Figure 4-33. Trend analysis of He leakage rate versus SAVY age for containers from 2015-2019.**

### *4.3.2 O-ring Discussion*

There were no significant O-ring issues found in the SAVY 4000 containers this year. There were small inclusions or scuffmarks seen but the issues did not affect the performance on the O-ring. Figure 4-34 shows durometer measurements versus SAVY age. There is variability in the measurements but no significant trend. The black horizontal lines are the acceptance limits, the blue line is the trend line, and the gray shaded area is the 95% confidence bound for the trend line.

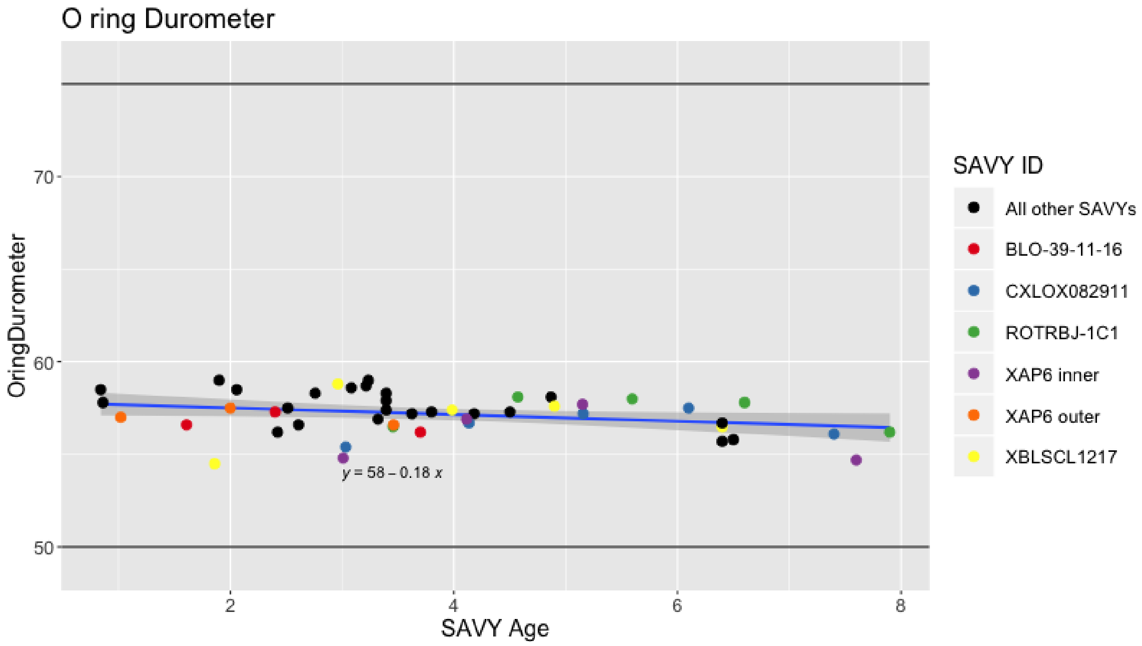



**Figure 4-34. Durometer measurements versus SAVY age.**

Figure 4-35 shows compression versus age. Details of how the compression data are collected and results for accelerated aging studies are provided in Weiss, et. al. 2016. The surveillance compression data were not collected in 2015 or 2016, there were three measurements in 2017 and in 2018 three measurements were made but two of those were estimated based upon the average gland size for containers. In 2019, there were compression set measurements for all containers ranging from 0.04 to 0.26. There was one container, POX4275C1, that had a negative compression set value (-0.049). This value was excluded in the analysis as the compression set values should be greater than zero. The compression set values are estimated based upon an initial O-ring thickness. The reported thickness may not have been correct for POX4275C1. Additionally, the measurement error reported for the O-ring thickness is 0.0454. The reported measurement for POX4275C1 falls within the margin of error.

Of the six containers with multiple measurements over time (multi-colored dots) only one has more than two measurements, BLO-39-11-16, which has three measurements. The compression set measurements indicate a positive trend. However, looking at the items that have multiple measurements there is not a positive increase except for XAP6 outer (orange dots). All other containers that have measurements over time are approximately the same value or slightly lower.  More data are needed before a trend can be reliably assessed.

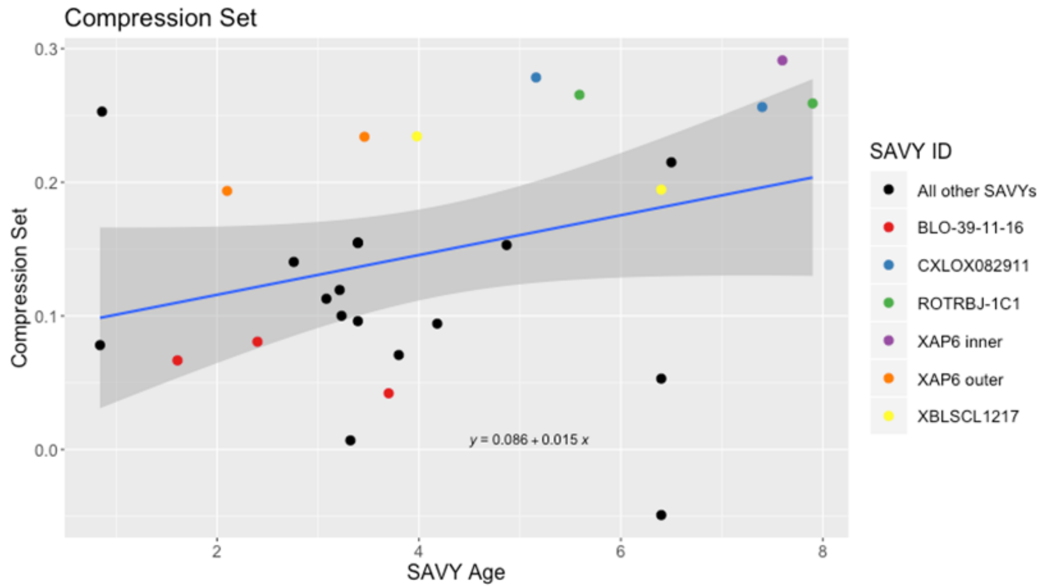



**Figure 4-35. Compression set versus SAVY age.**

### *4.3.3 Filter Discussion*

Figure 4-36 shows particle penetration versus SAVY age. This measurement depends on how long the data are collected and the collection time can vary between measurements. The variability in the collection time results in variability between measurements leading to scatter in the actual measurement values across the years. The gray shaded area is the 95% uncertainty band for the trend line. Although the trend appears negative, the variability of the data is such that the trend is not statistically significant. In addition, as shown in Figure 4-37 the measurements are small compared to the acceptance limit, the black horizontal line, and are within the variability of the measurements.

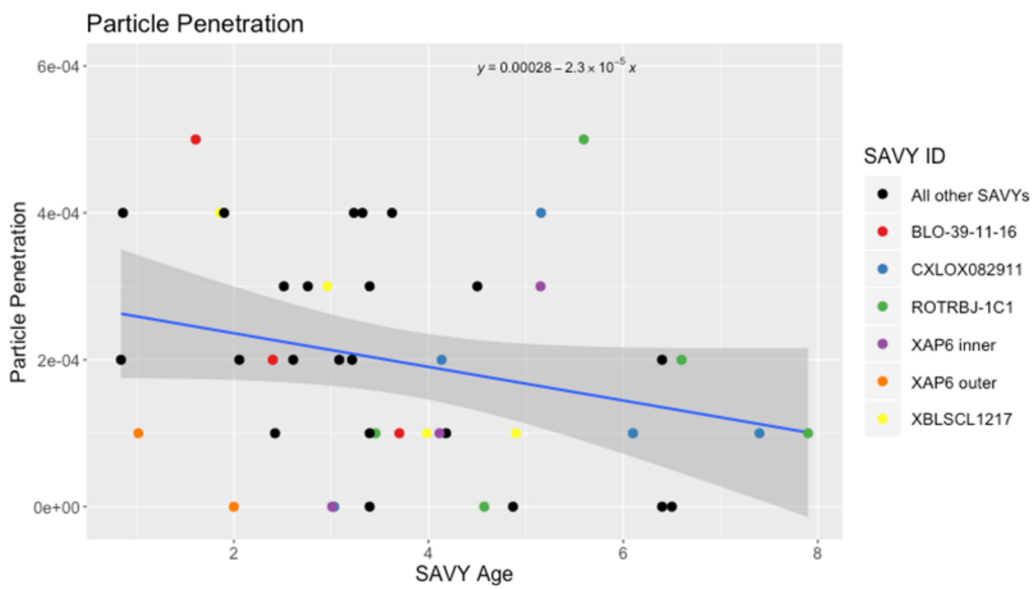



**Figure 4-36. Trend analysis of particle penetration versus SAVY age for SAVY containers in surveillance from 2015-2019.**

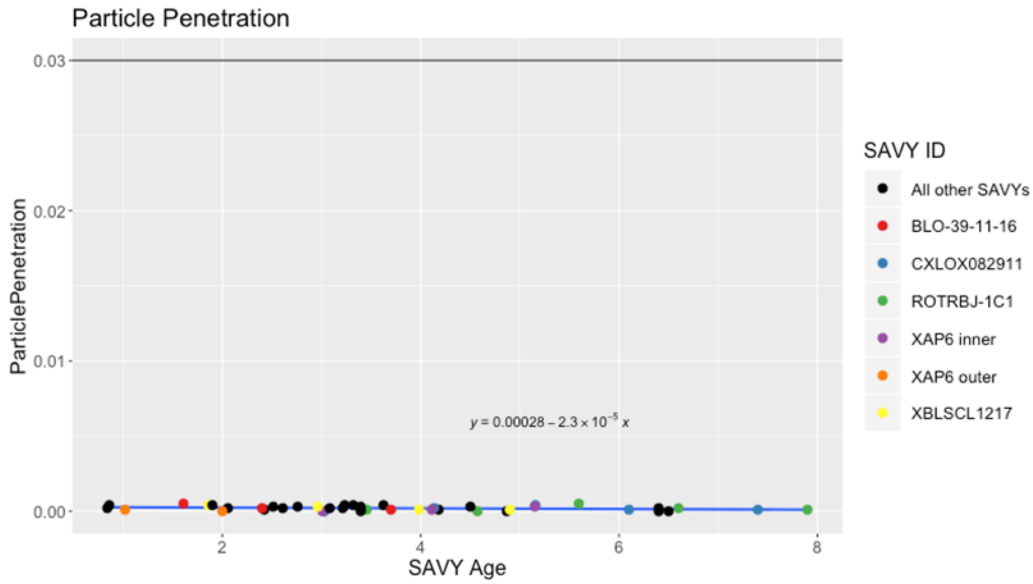



**Figure 4-37 Trend analysis of particle penetration versus SAVY age for SAVY containers in surveillance from 2015-2019 shown in context of acceptance limit.**

Figure 4-38 shows the plot of filter pressure drop versus SAVY age. Looking at all of the data, there is indication of a negative trend, however, there is considerable scatter and the five containers that have been measured multiple times (colored circles) show no change with age. A slight negative trend for this measurement would not be an issue given that the acceptance criterion does not include a lower limit. To date, all filters have passed acceptance testing.

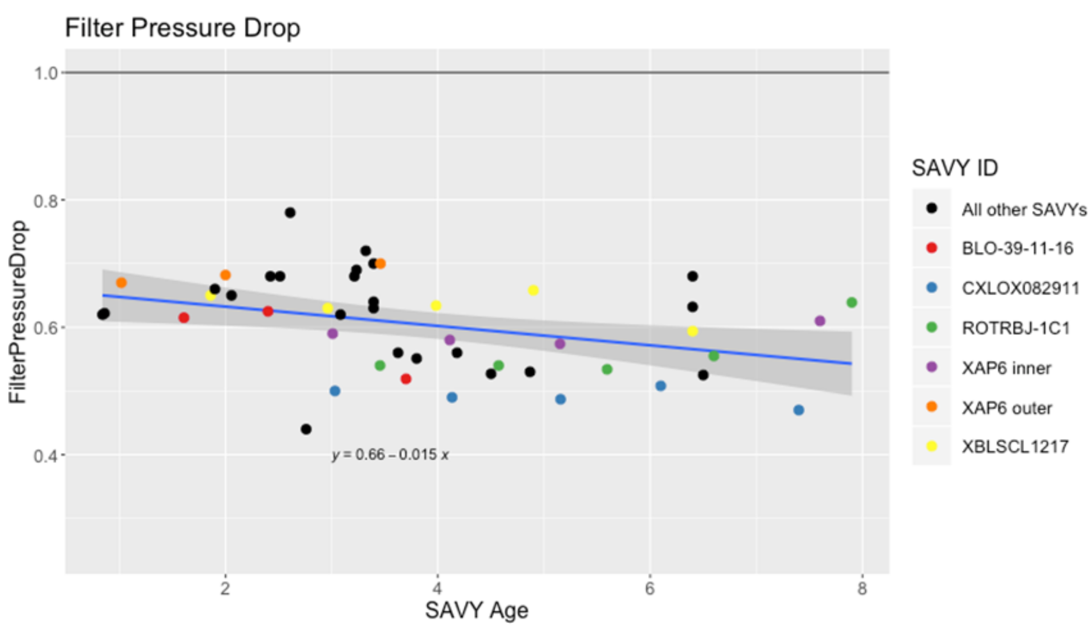



**Figure 4-38. Filter pressure drop versus SAVY age.**

### 4.3.4 SAVY-4000 Corrosion Discussion

The corrosion ranking scale was applied to all of the SAVY 4000 containers from 2015 to 2019. A total of 50 containers were ranked, with 6 containers that were in surveillance for multiple years. Of these, 33 had no corrosion and 17 had some level of corrosion. Only one SAVY container was ranked in category 3, the highest level of corrosion [8].

The plot of the corrosion ranking versus age (Figure 4-39) does not show changes with age. Of the containers that were in surveillance multiple years, XBLSCL1217 (yellow dots), XAP6 inner (purple dots) and ROTRBJ-1C1 (green dots) have changed states from the category of no corrosion, but stayed in the same state from 2018 to 2019. However, several of the older containers do not have any corrosion indicating age alone is not a major factor for corrosion. Other factors that may be associated with corrosion include not only age (a), but also wattage (w) and container size. The bag degradation factor (BDF) combines all three of these factors into a single value [9]. BDF is defined as age times wattage divided by the square of the radius of the container (BDF = a*w/r^2). Plots of corrosion ranking versus BDF show (Figure 4-40) a slight increasing trend, but it is not statistically significant ($p = 0.10$).

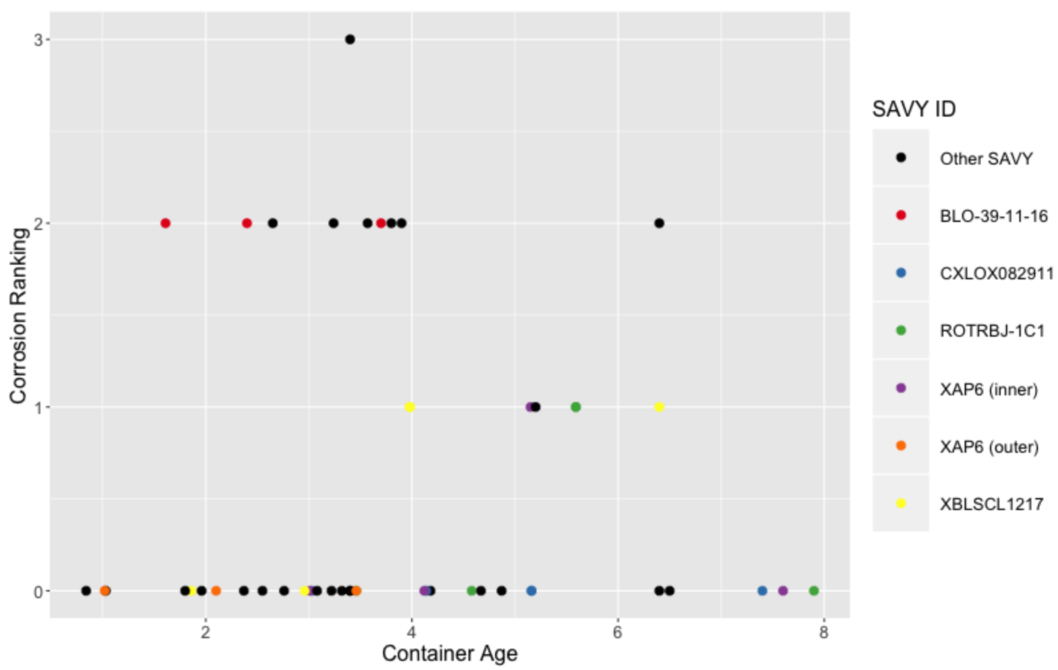



**Figure 4-39. SAVY 4000 container corrosion ranking vs. age**

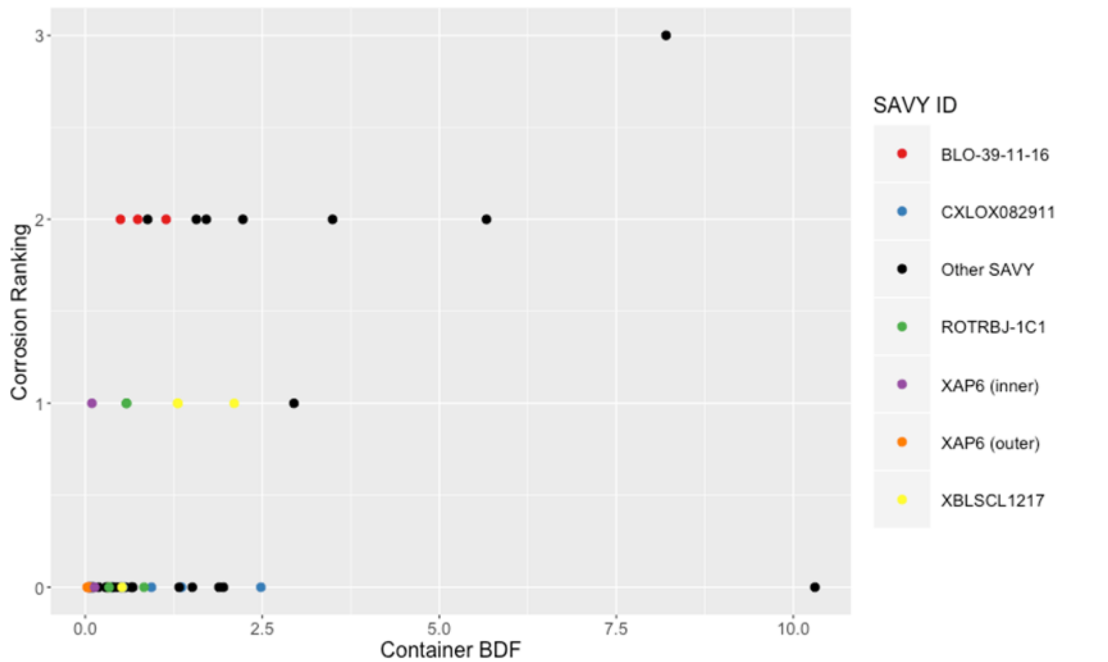



**Figure 4-40.** **SAVY 4000 container corrosion ranking vs. BDF**

### *4.3.1 Hagan Corrosion Discussion*

The corrosion ranking scale was applied to all the Hagan containers from 2013 to 2019. A total of 35 containers were inspected based upon visual analysis. Of the 35 containers ranked, 11 were labeled as having no corrosion and 24 had some level of corrosion, with eight Hagan containers labeled in category 3, the highest level of corrosion [8]. Again, factors that are associated with corrosion include age, wattage, and container size. Figure 4-41 shows a plot of the corrosion ranking versus age. The trending analysis shows there are no changes in the corrosion ranking due to age. The plot of corrosion ranking versus BDF, Figure 4-42, shows a slight increasing trend, the greater the BDF the higher the corrosion ranking. However, it is not a statistically significant trend ($p=0.10$).

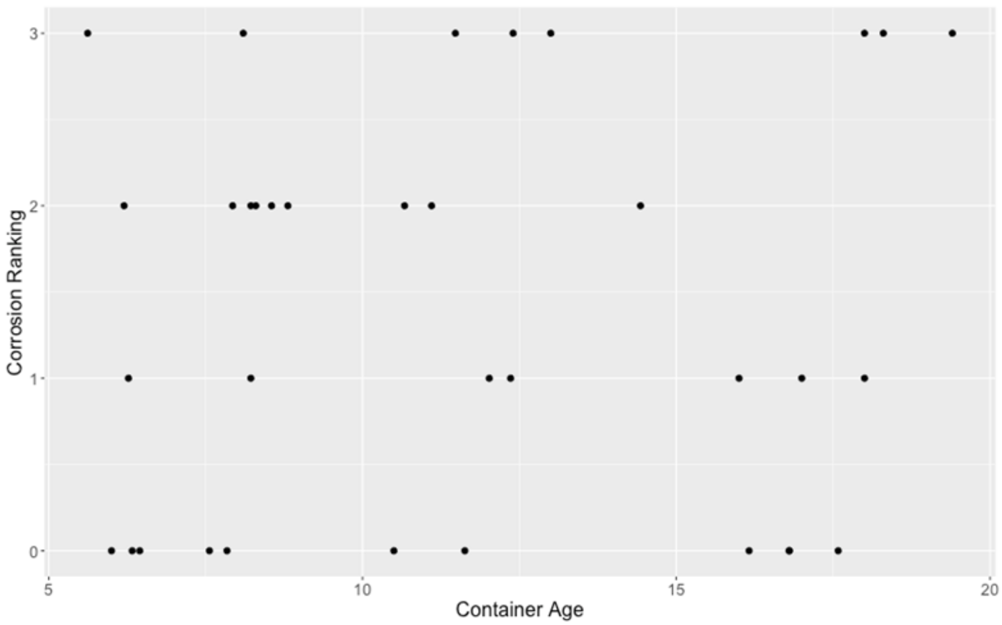



**Figure 4-41. Hagan container age vs. corrosion ranking**

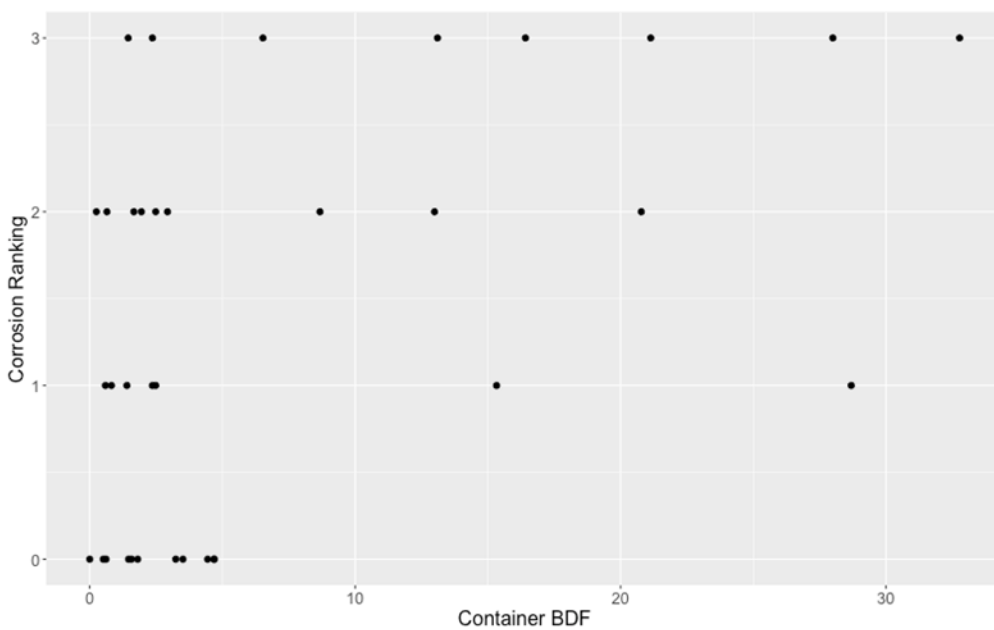



**Figure 4-42. Hagan container BDF vs. corrosion ranking**

The evaluation of trending of corrosion over time for the SAVY 4000 and the Hagan's, both show a slight trend for BDF, which incorporates factors such as age, wattage and container size. Additional data, such as items with a higher wattage, will help to determine how these factors impact corrosion. This information will guide selection future surveillance containers.

# 5 Summary and Conclusions

This year surveillance activities continued to reveal corrosion inside of the storage containers. Four of the five SAVY 4000 containers that were found to have minor corrosion on the inner surfaces were returned to service and will be surveilled going forward. The one SAVY container that was not returned to service will be brought out of the radiological control area for further evaluation. There were no failures of any of the components in FY19. The worst case of corrosion seen in FY19 was container 19H5, which clearly had corrosion beyond the sealing surface but did not have any contamination or evidence of corrosion on the outside surfaces. The fact that contamination has not been found on any of the container external surfaces indicates that the containers are performing their primary function of maintaining their contamination barrier and protecting the workers that use these containers on a daily bases.

In FY19 the engineering judgment (EJ) selection criteria of small containers with high wattage items inside for long periods of time was validated. A significant finding in FY19 was that 2 like items that were surveilled exhibited different levels of corrosion. The differences in these items leads the container subject matter experts (SMEs) to believe there are other conditions that have not been identified that may be contributing in the discrepancy of results. The SMEs have hypothesized that position relative to other items in their storage location may be a cause of the differences. However, the items were in opposite sides of the same room. This could be tested in future surveillance years by identifying containers that were packaged with similar characteristics.

# 6 Recommendations

## 6.1 In-glovebox Capabilities

An ability to evaluate container performance inside of gloveboxes would be a valuable improvement to the surveillance activities. Due to the number of containers being introduced into gloveboxes having the capability to measure; O-ring thickness, helium leakage testing and water ingress testing, would allow for information to be gathered on containers that would otherwise be lost.

## 6.2 Material Types and Forms

The FY20 surveillance plan should continue to focus engineering judgment (EJ) sampling on the 12 IDC groups identified as worst case materials. In particular, EJ sampling should target a Hagan packaged with MSE salt similar to 18H7, which had a large dose in a small volume container. The condition of this container was the worst seen to date in surveillance. However, in order to ensure that the surveillance program bounds the inventory of stored material, it is recommended that the surveillance program includes other nuclear material types and material forms in the storage population that could be comparable to plutonium. For example, neptunium (MT 82) and uranium-233 materials have not yet been sampled in surveillance and should be prioritized by factors such a dose and the potential for corrosion.

## 6.3 Random Sampling

In addition to EJ sampling, in FY20 it is recommended that a random sample of SAVY containers over five years of age be added to the surveillance program. The random sampling will provide confidence that an unexpected degradation, failure or usage mode for the SAVY containers will be identified. The approach of combining EJ and random sampling has been used in other container safety programs (e.g., the 3013 program) and is considered to be a cost-effective approach for ensuring the long-term integrity of storage containers packaged with nuclear materials. This random sampling approach will reduce the opportunity for annual surveillance, but based on the trends seen with the past annual surveillance items it will be more beneficial to let a few years lapse before those containers are surveilled again.

## 6.4 Like Item Comparison

Due to the fact that 2 containers with nearly identical items in them were found with significantly different amounts of corrosion it might be worthwhile to select some surveillance items that have like items in them. This could be used to identify the parameters for corrosion the storage containers.

## 6.5 Alternative Bag-out Bag Surveillance Item

In order to assess the real world performance of the alternative bag-out bag material (Aromatic Polyurethane), a surveillance item that would challenge the bag-out bag material should be selected. Results from the surveillance item that was bagged out in the new bag material will help to confirm other experimental results that suggest that removing PVC bags eliminate the primary cause of corrosion in the containers.

## 6.6 Photo Capability for Surveillance

It has recently been recognized that a capability to capture photos in the lab that surveillance takes place would greatly improve the effectiveness of evaluating the growth of corrosion in containers that are being surveilled on a regular basis. By capturing photos in the lab it would be possible to control the lighting so that the color of the photos remains consistent from year-to-year allowing a more comprehensive analysis to be completed on the photos that are captured. If a camera were available it would allow the container surveillance team to gather photos of every container that passes through the program.

## 6.7 Follow-up on Cause of Hagan Leakage Test Failure

A single Hagan container with substantial general corrosion failed the helium leakage test. Further testing is underway to determine the cause of failing the helium leak rate.

# 7 References

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10. McGill, Robert, Tukey, J.W., & Larsen, Wayne A. (February 1978). "Variations of Box Plots". *The American Statistician***. 32** (1): 12–16.
11. Reeves, Kirk et al., “Evaluating Corrosion Effects on the Stainless Steel Components of the SAVY-4000/Hagan Nuclear Material Storage Containers” (LA-UR-18-25709, Los Alamos, NM, 2018